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TARTALOMJEGYZÉK

A KORA ÚJKORI TÖRTÉNETI FÖLDRAJZ JELENTŐSEBB LEVÉLTÁRI FORRÁSAINAK MÓDSZERTANI ALKALMAZHATÓSÁGA

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Kivonat: A kora újkor középkorral összevethető forrásgazdagsága szembetűnő. A 16. század második felétől az írott források annyira megszaporodnak, hogy a történeti földrajzi adatokkal bírókat érdemes nagyobb csoportokra osztottan, forrástípusonként áttekinteni. Ezek között is a forrásképző felől két nagy csoportot lehet kijelölni: egyrészt az állami adójegyzékek nagy sorozatait, majd az országos összeírásokét, másodsorban a földesúri birtok (uradalmi) adminisztráció számottevő iratanyagát. A forrásokból származó statisztikai adatok térbeli megjelenítése új módszertan kialakítását igényli, amihez a korai térképi források, valamint a modern, területi adatokat megjelenítő, technikák alkalmazási lehetőségeinek vizsgálata szükséges. Egy-egy forrástípus a népesség számára, differenciálódására, a gazdálkodásra, a határhasználatra vonatkozóan nyújthat adatokat, melyek felhasználásával elkészíthetők a térbeli megjelenítések is.

***Kulcsszavak**: történeti földrajz, forrástípusok, országos összeírások*

1. BEVEZETÉS, TÖRTÉNETI FORRÁSOK A TÖRTÉNETI FÖLDRAJZ KUTATÁSÁBAN

A kora újkor vége Magyarországon szinte egybeesik az egész országra kiterjedő jozefiánus térkép megszületésével (1780–1784); így a kora újkorra vonatkozó történeti földrajzi vizsgálatok még csak ritkán használhatnak kellő részletességű egykorú térképi ábrázolásokat, mivel azok javarészt hiányoznak a forrásanyagból. Birtoktérképek jellemzően csak a 18. század második felétől elérhetők a kutatás számára, s ahol nem készült vagy nem maradt fenn ilyen, ott az első katonai felmérés térképlapjai jelentik az első határábrázolást. Ezzel szemben ami rendelkezésre áll, az az írott források viszonylag nagy tömege, melyeket célszerű forrástípusonként áttekinteni *(1. táblázat).*

Mindenekelőtt érdemes a forrástípus és iratfajta fogalmi meghatározásait rögzíteni. Az 1982-ben megjelent levéltári terminológiai lexikon (Ember 1982) a forrást olyan anyagnak tekinti, amely a belőle megtudható-meríthető ismeretekkel, adatokkal a múlt megismeréséhez járul hozzá. Az iratfajta jellemzően a keletkezésre vonatkozó formai jellemzőket takar, mint például: eredeti, másolat, fogalmazvány, tisztázat stb. A forrástípusra olyan példákat hoz a kötet mint urbáriumok, úriszéki jegyzőkönyvek, missilis levelek, számadások, minisztertanácsi jegyzőkönyvek, de eszerint forrástípus a kéziratos térkép is.

A középkori történeti földrajz művelői szinte csak egyetlen levéltári forrástípussal dolgoznak, nevezetesen az oklevéllel. A „szinte csak” kifejezés arra utal, hogy alárendelten más források is bevonhatók a kutatásba, azonban az oklevél, mint a középkor jogbiztosító irata nagyobb tömegben maradt fenn, ezzel mintegy uralja a középkori történetírást, ezzel együtt a középkori történeti földrajzot. Ezek között is talán a legelőkelőbb helyen az az oklevéltípus áll, amelynek tartalma a településhatárokkal kapcsolatos felülvizsgálat, határjárás és kijelölés (revisio, reambulatio et resignatio), amely így elsőként teszi „láthatóvá”, azaz leírva rögzítetté a legfontosabb földrajzi-közigazgatási – egyébként meglehetősen elvont – fogalmat, a határt. Ha vannak hosszú időn át fennmaradt, e korai iratokban leírt, ma is azonosítható tereppontok, akkor a település határvonala a mai térképeken is követhető. Ugyancsak nagy számban maradtak meg helynevek ezekben az iratokban, a lakosság folytonossága pedig egy-egy tájon a földrajzi neveket különösen szívós módon évszázadokig fennmaradóvá teszi, még ha a későbbiekben rajtuk némi torzulás is észlelhető.

1. táblázat

Főbb forrástípusok az iratképzők alapján csoportosítva

Állami adminisztráció	**Vármegyei adminisztráció**	**Uradalmi iratok**	**Faluközösség iratai**
• jogbiztosító iratok • dézsma- (tized-) jegyzékek • kincstári birtokok összeírásai és számadásai • népesség-összeírások • úrbérrendezési iratok	• portaadójegyzékek • közgyűlési jegyzőkönyvek és iratok • birtokba iktatási iratok (leltárak)	• birtokszerződések • urbáriumok • leltárak (inventáriumok) • becsűk • számadások • birtokperek jegyzőkönyvei • levelek (missilisek) • úriszéki iratok	• jobbágyszerződések • jobbágykérvények • jobbágypanaszok

Már Györffy György Árpád-kori vármegyéket bemutató történeti földrajzi kötetei (Györffy 1693–1998) évkörének felső határát sem okleveles forrás adja, hanem a pápai tizedszedők (egyébként Anjou-kori) lajstroma, s ez egyben azt is jelzi, hogy a különböző adójegyzékek kiválóan hasznosíthatók egy-egy közigazgatási egység együttes vizsgálatához.

2. FORRÁSTÍPUSOK A KORA ÚJKORI TÖRTÉNETI FÖLDRAJZ KUTATÁSÁHOZ

A kora újkortól az egyházi (tized) és állami (portális) adójegyzékek nagy számban állnak rendelkezésre a Magyar Kamara Archívumában (Maksay 1992). Miután a 16. század második felétől jellemzően az állam veszi bérbe az egyházi tizedet a végvárak ellátása céljából, lényegében ez is állami beszedésű adóvá válik. Az adóadminisztráció révén bizonyítható egy-egy település megléte a kora újkorban, amikor nem egyszer időlegesen vagy véglegesen pusztává válnak egyes falvak.

Az országgyűléseken elrendelt évi hadiadó beszedésére készült vármegyei portális (illetve az 1598 és 1608 között ezt felváltó ház- vagy füst-) összeírások a település erejére, népességére adnak adatot, olykor egyes megyéknél az adózó családfőt feltüntető névsoros jegyzékek is fennmaradtak, bár legtöbbször csak az összesítő portaszámmal jellemzik azt (Bakács 1957). Miután 1548-tól a hódolt falvak csak az évi adó felét kötelesek fizetni, a töröknek való adófizetést is szerepeltetik ezek az összeírások, ezek pedig a meghódolt területek folyton változó határát jelölik ki. Az adatsorok egészen 1696. évi összeírásig szolgáltatnak adatokat.

A jobbágynépesség által használt földterületek, azaz a ténylegesen megművelt, „megélt” határ nagyságára nézve a legtöbb adatot a dézsmajegyzékek szolgáltatják (Ila 1957). Ezekből több típus is létezik, elsősorban a termesztett gabonák tizedét jegyezték fel, s ugyanezen a jegyzéken szerepelnek a méhkasok/méhrajok megváltására vonatkozó adatok is. A gabonákat az aratást követően, még a falu szérűjén mezei mértékekben adminisztrálták, az adott kor és táj szokásainak megfelelve kéve, kalangya, kereszt az adó alapegysége. Szerencsés, ha az ún. cséplési jegyzék is fennmaradt, ebből már az összesített szemtermés is látszik (többnyire köblökben). A bortizedjegyzékek pedig a termett bor mennyiségére, végső soron a szőlőhegyek kiterjedésére adnak adatokat. A bort nagyobb községeknél dűlőnként írták össze, ezzel a dűlők, szőlőhegyek neveit hagyták az utókorra. Mindkét jegyzékre igaz, hogy a termésmennyiség egyszerre utal a földműves jobbágynépesség számosságára, illetve a hozzájuk rendelt kültelki szántóföldek által elfoglalt területre, mind az adott esztendő éghajlattól függő termésviszonyaira. Juhot, esetleg kecskét tartó pásztorközösségek, módosabb jobbágyok az állatok szaporulatából is tizedet voltak kötelesek szolgáltatni. Itt a legelőterületek megléte megállapítható ugyan, de a mennyiségi becslés bizonytalan adatot eredményezne, ami számítható, az az adó alá vont állatállomány. A helyben maradó papi adórész (oktáva – nyolcad, sedecima – tizenhatod) átvételét igazoló korai nyugták pedig mind egyben a vallásföldrajzi adatot is jelentenek, kirajzolható belőlük egy-egy – főként protestáns – anyaegyház a filiáival. A dézsmajegyzékekben találni megjegyzéseket (a csökkenő adó okán) az elemi csapásokra, járványokra, időjárásra, a folyók áradásaira, de feljegyeztek sáskajárást, nagy szárazságokat is.

A földesúri nagybirtokok (uradalmak) irat anyaga ritkán őrzött meg az egyes jobbágyokra vonatkozó esztendei adójegyzékeket. A kilencedre vonatkozóan általános irat a jobbágy és földesúr viszonyát rögzítő urbárium, amelyben (az irattípus kiforrottabb változatában) a jobbágytelkek is szerepelhetnek, azok differenciálásával (egész- és félhelyek, további töredékhelyek, zsellérek, szabadosok stb.) (Maksay 1957). A bel- és kültelekből álló jobbágytelkek összessége mutatja a falu belterületének és a lakói által használt – szántóföldi termeléssel és rétgazdálkodással érintett – határrész kiterjedését. Olykor az elpusztult falvak után gazdátlan maradt kültelkeket is bérlik a jobbágyok, azaz hogy egy falu pusztává lett, nem jelenti azt, hogy a határában nem találni megművelt területeket. Jellemzően a 17. századi forrásokban már – talán a jobbágyháztartások erejének érzékeltetésére – az adó alá nem eső számosállatok (ló, tehén, ökör, tinó, sertés) számát is feljegyzik, ezzel egy-egy uradalomban tenyésztett állatállomány is becsülhetővé válik. Az urbáriumok mellett még többféle összeírás is született az egyes uradalmakban, mint a birtokleltárak, egyéb összeírások. Ezekben mind a jobbágyokra, mind pedig az uradalom saját használatú birtokaira, a majorságok elhelyezkedésére, az állatállományra, raktáron lévő gabonára, borra találni adatokat. Az uradalmi iratok között talált iratfajta még a becsű (aestimatio), amely a birtok hozzávetőleges értékét adja meg, a jobbágyok, telkek számával, a földesúri jövedelmekkel, a majorságok leírásával, a földesúri haszonvételekkel. Az összeírások szerepeltetik az uradalom területén működő vízimalmokat, ezzel együtt a terület vízrajzát is rögzítik.

A családi levéltárak gyakran külön kezelték az egyes birtokokra (falvakra) vonatkozó jogbiztosító iratokat, a jobbágyok egymás közötti szerződéseinek másodpéldányait, zálogleveleket, birtokpereket, a gyakori „határvillongások" miatt újkori határjárási (határkijelölő) jegyzőkönyveket. Különösképpen az utóbbiakban sok helynév, ezzel együtt a táj állapotleírása őrződött meg (Takács 1987).

Kifejezetten időigényes munka a nemesi családok levéltáraiban sokszor külön egységet jelentő levelezések áttekintése, még ha az egy-egy földrajzi területhez is kötődik. A területen működő, a földesúrnak évente többször is, de legalább az éves elszámoláskor jelentő uradalmi tisztek, hadvonulásokhoz kapcsolódó helyzetjelentések stb. számtalan új adattal gazdagíthatják a történeti földrajzi képet. Az uradalmi tisztek jelentéseiben a gazdálkodásról, a jövedelmekről és a gazdaságban jelentkező nehézségekről, például a gazdálkodást hátráltató időjárásról, elemi csapásokról találni leírást. Utóbb példaértékű feldolgozása történt a Rába vízrendszeréhez tartozó környezettörténeti adatoknak, melyhez éppen a missilisek jelentették a kiemelt forrástípust (Vadas 2021).

Az uradalmak úriszékei előtt lefolyt büntetőperek, jobbágyügyek vizsgálatai, jobbágypanaszok iratai ugyancsak tartalmazhatnak földrajzi adatokat, hiszen olykor az adott jogsérelem helyszínét is bemutatják, topográfiai adatokat rögzítve. A szökött jobbágyok ügyei, a telepítési szerződések pedig a migráció földrajzi adatait szerepeltetik.

A történeti statisztika nagy jelentőséget tulajdonít az országos népesség-összeírásoknak. Az utolsó vármegyei portaösszeírás (1696) után, a Rákóczi-szabadságharcot követően az egységes elvek alapján felvett 1715. és 1720. évi összeírás ad számot az ország adózó jobbágynépességéről (Dávid 1957). (Az 1720. évi egyébként a megelőző helyesbítése végett felvett összeírás.) Ezzel együtt a település határának használatára (szántók, irtványok, rétek, szőlők, legelők, erdők, malmok stb.) is fogalmaztak meg kérdést az összeírás szerkesztői. Erdélyben 1750-ben készült országos összeírás (Trócsányi 1957). Itt a bonyolult történeti fejlődés azonban azt hozta magával, hogy több kérdésben nem volt egységesen rögzített fogalom, így a teleknagyság sem volt még egy településen sem állandó, de többek között problémát okozott a házak, a nemesi és jobbágyföldek közötti átmenetek számbavétele is. Ennek ellenére az erdélyi összeírás egyedülálló munka.

A Mária Terézia-kori úrbérrendezés (1767–1771) ugyancsak egységes szabályozása teszi lehetővé, hogy nagyobb áttekintések és összevetések születhessenek egy-egy földrajzi egységről (Felhő 1957). Az iratanyag a 9 kérdőpontra adott válaszokat, az ezzel együtt felvett birtokállapotokat, az új nyomatott urbáriumot, valamint az úrbéri tabella együttesét jelenti. Miután egységesen kerül meghatározásra a jobbágytelek mérete, a bel- és kültelkek egzaktul számíthatók. (A beltelek mérete akkora területtel egyenlő, amelybe két pozsonyi mérő mag vethető, a termékenység szerint ez 1100–1300 négyszögöl, a kültelek az osztályba sorolástól függően 18–24 hold szántó, 6–22 kaszás rét.)

Szinte csak demográfiai adatokat adnak a II. József-kori népszámlálások, itt is ismétlésre volt szükség (1785, 1787) (Acsádi 1957). Valójában kizárólag csak a községsoros adatokat öszszesítő ívek maradtak fenn a vármegyei levéltárakban, az egyes falvak felvételi ívei elvesztek, azonban ami megmaradt, az egyedülálló módon tudósít a 18. század végi Magyarország társadalmáról.

3. ÖSSZEFOGLALÁS

A kora újkori történeti földrajz kutatását nagy iratanyaggal segítik a levéltárak. Elsődlegesen a nagy országos áttekintető összeírások felől érdemes közelíteni egy-egy terület vizsgálatát, s aztán még számos apróbb adattal finomítható a felvázolt kép. Forrásadottság szempontjából szerencsés, ha a település uradalmi kötelékben volt, mivel az uradalmi adminisztráció irattermelése fontos adatokat rögzített. A népesség számára, differenciálódására, a gazdálkodásra, a határhasználatra vonatkozóan nyújthat adatokat egy-egy forrástípus. A doktori képzés során ezeket az adatokat és iratanyagokat igyekszünk feldolgozni a Földrajzi Információs Rendszer (GIS) és a társadalomföldrajzi statisztikai módszerek (SPSS) alkalmazásával, ezzel egyedi térbeli információkat szolgáltatva a vizsgált területekről.

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AZ URBÁRIUM MINT A KORA ÚJKORI TÖRTÉNETI FÖLDRAJZ EGYIK FORRÁSA A SZÁDVÁRI URADALOM (TORNA VM.) PÉLDÁJÁN

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Kivonat: A kellő részletességű térképi ábrázolások megjelenése előtt kizárólag írásos források állnak rendelkezésre egy-egy terület történeti földrajzi képének felvázolásához. Különösen szerencsés, ha egy olyan gazdasági egységet tekintünk át területi egységében, mint az uradalom, amelynek levéltárakban fennmaradt gazdasági irattermése nagyszámú adatot tud szolgáltatni ehhez. A gazdasági iratanyagban kiemelt a jelentősége egy irattípusnak, nevezetesen az urbáriumnak mint a jobbágy és a földesúr közötti jogviszonyt rögzítő írott szerződésnek. A urbárium tájtörténeti, tájhasználati forrásként is használható azzal, hogy mind a társadalomra, mind pedig határban jelenlévő allódiális és úrbéres földekről, a mezőgazdasági kultúrákról számot ad.

***Kulcsszavak**: szádvári uradalom, urbárium, történeti földrajz, tájhasználat*

1. BEVEZETÉS, A FORRÁSTÍPUS BEMUTATÁSA

Az urbárium fogalma leggyakrabban a Mária Terézia-kori úrbérrendezéssel (1767–1780) összefüggésben jelenik meg a hazai (köz)történetírásban, holott az irattípusból a 18. század második felére számottevő mennyiség keletkezett, s gyűlt föl a nemesi családi és kincstári levéltárakban. Talán nincs is még egy olyan irat, ami pillanatfelvételként kezelve a benne lévő adatokat, az uradalmak gazdálkodását ennyire részletgazdagon tudná reprezentálni, mint az urbárium.

A szó eredetileg délnémet eredetű, törzse a későbbi „úrbér” szavunkkal azonos. Olyan feljegyzést értünk alatta, ami a földesúr saját birtokát, illetőleg a paraszti használatban lévő „úrbéres” (azaz nem majorsági) birtokát, továbbá a birtokból befolyt jövedelmeket és hasznokat rögzíti (Maksay 1957). Mindezek mellett fontos ismérve az iratnak, hogy utóbb az adózó jobbágyokat és zselléreket is számba veszik. Enélkül az irat inkább tekinthető jövedelem- és szolgáltatáslajstromnak, állapotkimutatásnak; noha a korai urbáriumok nem egyszer ilyen kivonatosan hiányos dokumentumokat jelentenek. A körülírt földesúr–jobbágy jogviszonyból következik, hogy az irat csakis egy uradalomban jöhetett létre. Így a szövegek helyben születtek, a helyi társadalom és az uradalom erőforrásainak alapos ismeretében, többnyire valamely uradalmi tisztviselő által, s ahogy arra számtalan utalás történik, a helyi elöljárók kikérdezésével.

Közép-Európában a 12. századtól készültek egyre részletesebb urbáriumok, majd Magyarországon a 15. század második felében jelentek meg. Az első (1451) hazai helységekre – a kőszegi és rohonci uradalmakra – vonatkozó ugyan osztrák birtokadminisztráció terméke (Bariska 1998), azonban szimbolikusan jól mutatja, hogy az egyes kancelláriai és magánjellegű forrástípusoknak rendre nyugat-európai előzményüket találjuk.

Majd az 1476-os évből két irat is fennmaradt, amit urbáriumnak is tekinthetünk: az egyik nemesi kézen lévő, a másik egyházi birtoké. A maróti birtokok összeírása bár még csak a jobbágytelkeket veszi számba a jövedelmekkel, viszont (körzetekbe sorolt) községek szerint rendezi az adatokat, míg az egri püspöki irat ünnepenként csoportosítja a szolgáltatásokat és a robotot rögzíti (Maksay 1957). A középkori urbáriumok közül többnek a forráskiadása is megjelent, így a vásárhelyi (1511), a kisvárdai (1521), a beckói (1522), a szenyéri (1524), a veszprémi (1524), a világosvári (1525), illetve az előbbiek szerkezetét nem követő gyulai (1525) urbáriumé (Kredics & Solymosi 1993). Miután a későbbiekben Torna vármegyei települések urbáriumával foglalkozunk, már itt megjegyezzük, hogy a (szádvári uradalommal szomszédos) tornai uradalom középkori urbáriuma is fennmaradt, bár az egyelőre még kiadatlan (MNL OL, DL 37169).

A legnagyobb számban azonban az újkorból maradtak fenn urbáriumok. A 16–17. századiakból mindmáig a legterjedelmesebb válogatás 1959-ben jelent meg (Maksay 1959), azóta sem készült olyan munka, amely ezt a szövegkorpuszt meghaladná. A kutatást ugyanakkor segíti, hogy a Magyar Nemzeti Levéltár Országos Levéltára egyik legtöbb – főként a kincstári birtokok – urbáriumait őrző gyűjteménye, a Magyar Kamara Levéltára Urbaria et conscriptiones iratanyaga digitalizált formában online kutatható (https://archives.hungaricana.hu/hu/urbarium/). Valójában egészen az úrbériség végleges megszűnéséig (1848, illetve 1853) készültek ezek az iratok, bár a Mária Terézia-kori úrbérrendezés után már egyre kevesebb (Maksay 1957).

2. A SZÁDVÁRI URADALOM 16–17. SZÁZADI URBÁRIUMAI

Szádvár váruradalma a középkorban született meg, a birtokait jelentő falvak elhelyezkedését tekintve javarészt Torna vármegyében, amihez majd a Bebekek csatoltak hozzá további gömöri településeket a Mohács utáni zavaros időszakban (Détshy 2004). Teljes területével a Gömör–Tornai-karszton terjeszkedik, a Szilicei-fennsík, Felső- és Alsó-hegy, Tornai-dombság, Galyaság, Bódva-völgy és Sajó-völgy kistájakat érintve.

Egy-egy új urbárium létrejöttét gyakran a birtokosok változása, lényegében az új birtokos megjelenése eszközölte ki. Az ismert szádvári urbáriumok megszövegezésekor is rendre ezt találjuk. Bizonyos, hogy a 16. századi Bebek-birtoklás alatt is rendelkeztek ilyen úrbéri szerződéssel a uradalom falvai, azonban ez nem maradt ránk. A vár és uradalma birtoklástörténetébe gyökeres változást a kamara 1567 elején bekövetkezett konfiskálása hozta: Lazarus von Schwendi foglalta el a várat, s tette királyi végvárrá.

Az első kamarai urbárium nem maradt ránk, csak annak az 1568-ban – Sóry Pál udvarbíró alatt (Détshy 2004) – készült kivonata (ÖStA, FHKA, HFU, VUG, Fasz. 5., Nr 114., ff. 1–6.). A jegyzék kereken húsz helység adatait villantja fel: az említés rendjében Szögliget, Szilas, Jablonca, Almás, Görgő, Borzova, Hidvégardó, Szilice, Szőlősardó, Perkupa, Szin, Szentandrás (Kovácsival), Berzéte, Varbóc, Körtvélyes, Kápolna, Vendégi, Szalóc és Vígtelke. A három gömöri falu, Berzéte, Szalóc és Vígtelke kivételével mindannyian tornaiak. A kivonat közli az egyes helységekben a jobbágyhelyek és a zsellérek számát, ugyanígy a lakatlan (puszta) helyekét, illetve az évente várható cenzust, az egyéb jogcímen elvárt jövedelmeket (sertésdézsmát és méhrajok megváltását jelentő pénzösszegeket, a természetben fizetett kender-, bor- és gabonakilencedet és -tizedet, illetve a malmokból származót). Szerencsés, hogy Szádvár egykorú számadáskönyve is fennmaradt (ÖStA, FHKA, HFU, VUG, Fasz. 5., Nr 114., ff. 8–21.), ez tovább árnyalja a gazdálkodást, s ad a termelvényekre, az uradalom topográfiájára – például a malmok elhelyezkedésére – vonatkozóan adatokat.

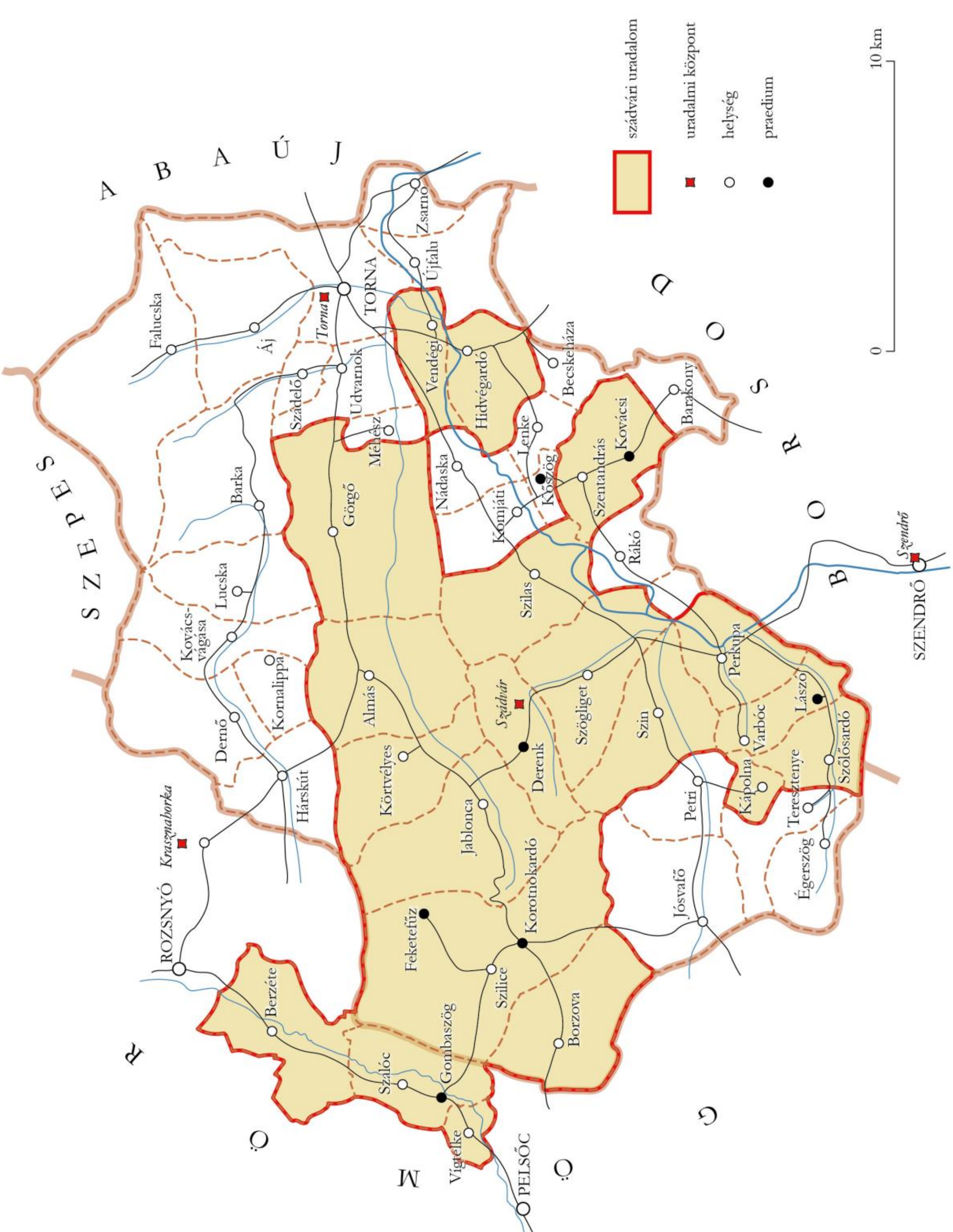
Az első teljes urbárium 1570 nyarán született annak kapcsán, hogy a Szepesi Kamara Richel Ágoston kapitánynak adta bérbe a várat három esztendőre (Détshy 2004). Az irat három példányban is fennmaradt (MNL OL, E 156 a., Fasc. 65., No 84/a., pp. 31–72.; [a margójegyzetekben 1575. évi adatokkal]. További két egykorú, Berzéte összeírását is tartalmazó példánya: uo., No 84/b., pp. 89, 91–125.; uo. Fasc. 86., No 3/a., pp. 53–88. [Ennek 1768-i másolata: uo., pp. 153–202.] Az MNL OL, E 156 a., Fasc. 65., No 84/a., pp. 31–72. kivonata uo., No 84/c., pp. 1–8, 11–12, 25–30.; illetve a Berzétét is tartalmazó változat kivonata: ÖStA, FHKA, HFU, VUG, Fasz. 5., Nr 114., ff. 23–29.), ezek filológiai összevetés után rejtenek különbözőségeket, melyek nem a szokványos másolatkészítés során jöttek létre. Azonban az uradalom birtokolt falvai tekintetében nincs változás (1. ábra). Két lényegi különbséget lehet rögzíteni. Két példányban megtalálhatók Berzéte adatai, míg a harmadikból kimaradt. A harmadik tisztázati példány ugyanakkor a később, 1575-ben margóra jegyzett adatok miatt értékes. Ez különösen szemléletesen rögzíti az 1570 után lezajlott társadalmi változásokat, elsősorban az – oszmán pusztítások hatására lezajlott – jobbágymigrációt (megadva az elköltözők akciórádiuszát). Mind a Berzétét is tartalmazó, mind az azt nélkülöző példánynak is maradt fenn egy-egy kivonata, ráadásul ezek olykor az alapszövegtől eltérő megállapításokat is tartalmaznak.

Az 1570-es urbáriumsorozat az első teljes szövegű urbáriumokat tartalmazza. Az egyes települések adatait rendező fejezetek birtoklástörténeti összefoglalással kezdődnek, megadva, hogy az adott falu örökös birtok-e (azaz a várbirtok eredeti része-e), avagy később szerzett jószág, ha utóbbi, az mi módon történt, továbbá, ha a füleki szandzsák adminisztrációja már bekebelezte a falut, akkor utalnak a töröknek való adófizetésre. A második részében felsorolja a jobbágyhelyeket az azokat bíró jobbágyok megnevezésével, telekméret szerint csoportosítva. Eszerint egész-, fél, de egy falunál (Szilas) további töredéktelkesek, harmad- és negyedtelkes jobbágyok is szerepelnek. A pénzben fizetett adó (cenzus) és jövedelem (proventus) leírásánál gabonaféléket (árpa, zab, tönköly, búza), tűzifát, bort, méhrajt, bárányt, sertést említenek az összeírások; a földesúrnak járó ajándék gyanánt pedig többnyire hízott ökröt, ritkábban baromfit, nyulat adnak. Külön bekezdést kap a földesúr saját tulajdonaként említett majorság és más földesúri haszonvételek, ezek leggyakrabban szőlők, kaszálók, szántók, illetve malmok, híd- és szárazvámok. Az egyes településeket leíró részt a helyben szokásban lévő bírságpénzek és a különböző szolgálatok (robotmunka) meghatározásai zárják.

1576-ban újabb urbárium készült Saurer Erhardt udvarbíró számára, erről a következő esztendőn készült egy másolat, immár Sóry Pál udvarbírónak, s ugyanebből az évből (1577) még egy kivonat is rendelkezésre áll (MNL OL, E 156 a., Fasc. 65., No 85/a., pp. 14–53.; Uo., No 85/c., pp. 54–93., utóbbi kivonata: Uo., No 85/b., pp. 1–13.). A források szerkezete az 1570. évieket követi. A bekövetkezett változások összevetésére a földesúr saját használatú (majorsági) birtokainak leírása teremt alkalmat, mindazonáltal a vár szükségeire kikényszerített megnövekedett szolgálatokra a jobbágyok közös panasza utal.

A 17. század elejéről újabb urbáriumokat ismerünk, az 1604. esztendei egy 1594-ből valót követ, és Dersffy Ferenc birtokaként rögzíti a szádvári uradalmat (MNL OL, P 72, Fasc. 480., No 4., pp. 22–52.). Az 1605 nyarán írott már Csáky Istvánnak rögzíti az uradalom jobbágyhelyeit, adóit és jövedelmeit (MNL OL, E 156 a., Fasc. 86., No 3/a., pp. 1–28. [1768. július 12-i másolata: uo., No 3/b., pp. 114–152.]). A két egymást követő esztendőben született forrás összevetése azért is különleges, mert egyértelmű, hogy két önálló munkáról van szó, a későbbi nem egyszerű másolat, hanem újabb adatfelvételezésen alapul.

1648 körül, minden bizonnyal Csáky László részére szövegezték Szádvár első magyar nyelvű urbáriumát (MNL OL, P 108, Rep. 24., Fasc. M., No 472., pp. 1–131.). Az irat immár egészen új formulát használ az uradalom leírására, jobbágyadatai kiegészülnek az egyes jobbágyháztartások kondícióira vonatozó számadatokkal (ló, ökör, fejőstehén, borjú, juh, kecske, sertés, méhkas, szőlő), a hiányzó jobbágyok elszármazását is legtöbbször településnévvel megemlíti, ezek főként abaúji és borsodi falvak, ugyanakkor Törökországba hurcolt rabok is



1. ábra
A szádvári uradalom kiterjedése az 1570. évi urbárium szerint
(rajzolta Vécsei János)

feltűnnek (Görgő, Szögliget). A 17. századból további urbáriumot nem ismerünk, de miután a 17. század második felében a Csákyak alatt részbirtokokra szakad az uradalom, az egyes birtokosok számadásaiból következtethetünk a változásokra. Az uradalom majd csak Esterházy Pál kezén egyesül újra Thököly, majd Rákóczi mozgalmának kihunytát követően, s a birtokadminisztráció újra urbáriumot is magába foglaló összeírásokat is szövegez.

3. TÖRTÉNETI FÖLDRAJZI ADATOK AZ URBÁRIUMOKBAN

A történeti földrajz hazai, elsőnek tekinthető szabatos fogalmi meghatározását a történész Györffy György adta 1963-ban, az egyelőre csonkán maradt Az Árpád-kori Magyarország történeti földrajza sorozat nyitókötetének előszavában, miszerint „tárgya egy terület adott történeti korban fennállott természeti, gazdasági és társadalmi viszonyainak földrajzi szempontból rendszerezett leírása történeti források alapján” (Györffy 1963). Somogyi Sándor 1988-ban a fogalom földrajzi megközelítését adta akként, hogy a múlt leíró földrajzaként definiálta, s múlt alatt azon korok értendők, melyek az ember beavatkozásaitól már nem mentesek (azaz történeti korok), ezzel együtt önálló tudományágként „a táj egykori állapotáról ad hű és megbízható, a tájalkotó tényezők időben és térben változó kapcsolatának felismerésén és magyarázatán alapuló leírást” (Somogyi 1988).

Ha sorban áttekintjük a fenti definíciókban foglaltakat, akkor mindenek előtt a terület, azaz az uradalom mindenkori határait kell vizsgálnunk, majd a történeti táj alkotóinak időbeni változását, esetünkben a falvak jobbágynépessége által használt határ módosulásait. Miután az urbáriumok pillanatfelvételek, ezek idősorba rendezve a mindenkori változást reprezentálják. Szádvár birtokainak gyarapítása a Bebekekhez kötődik, a gombaszögi pálosoktól elfoglalt falvak mellett elsősorban a jobbágyok kezén lévő szőlők erőszakkal való elfoglalásában jeleskedtek. Az uradalom új földesurai a családi osztozkodások, illetőleg a gazdálkodásukban jelentkező adósságok miatt a 17. század közepétől kényszerültek egyes falvak elzálogosítására, így azok hol időlegesen, hol teljesen lemorzsolódtak az uradalomról. Ezek nyomon követése térképen ábrázolható, hiszen a falvak határai évszázadokon keresztül közel állandóak, akár a 19. századi térképek is alkalmasak a kora újkori viszonyok rekonstruálására.

Fontos a település belterületének elhelyezése a térképen, lehetőleg minél kisebb léptéket alkalmazva, az egykori faluhely kijelölésével. A jobbágyhelyek összesített adatai számíthatóvá, de legalábbis becsülhetővé teszik mind a belterület kiterjedését, mind pedig a határ használatát, ha úgy tetszik a falu népessége által összes megművelt területeket. Ehhez azt kell tudnunk, hogy a telekhez (=jobbágyhelyhez) arányosan külterületi szántó és kaszáló tartozik. Egy egésztelek után járó földmérték konkrét nagysága tájanként változó (a Torna megyei adatok összevetése még várat magára). Olykor ún. pázsithelyekkel bővül egy-egy falu belterülete, azaz a jobbágyok (zsellérek) a kiosztott jobbágyhelyeken kívül is házhelyet foglalnak a falu gyepén.

Ugyancsak becsülhetők a földesúr saját használatú területei, a majorságok (allódiumok), ezekre vonatkozóan mindig pontos adatok szerepelnek, így például megadják, hány szekér szénát teremnek, hány jobbágy napi munkája szükséges a megművelésükhöz (rétnél lekaszálás, szőlőnél megkapálás). Ugyanakkor azt is el kell mondani, hogy a jobbágyok kezén lévő szőlőterületek számbavételére az urbáriumok nem annyira alkalmasak. Itt az egykorú – Torna vármegyében a korszakban nagy számban fennmaradt – dézsmajegyzékek (MNL OL, E 159 a., 206–212. cs.) vizsgálata lehet célravezető, a beszolgáltatott bortizedekből ugyanis visszakövetkeztethető (számítható) a termés, s ez pedig a szőlőhegyek (promontóriumok) kiterjedését is becsülhetővé teszi. A dézsmajegyzékek természetesen a termett gabona mennyiségére is pontosabb adatokkal bírnak, hiszen a beszedett tizedből számíthatóvá válik a termés, a cséplési jegyzékekből a kinyert szem mennyisége, végső soron a termésátlagok becslésével az a földterület is meghatározható, amit egy-egy jobbágyközösség megművel.

Az urbáriumok elsősorban az allódiumoknál szerepeltetnek helyneveket, hiszen ez a célravezető topográfiai meghatározás ebben a forrástípusban. A helynevek pedig meglehetősen szívósak, amennyiben a tájat lakosságfolytonosság jellemzi (ez a szádvári uradalom egy-egy török korban elnéptelenedett települését kivéve így is van), hajlamosak hosszabb időn át is fennmaradni, akár a mai térképek helynévanyagával, illetve a helynévgyűjtések anyagával is összevethetők. Az 1648 körül készült urbárium ettől is bőbeszédűbb, a Szilicei-jégbarlang egyik korai leírását adja. De topográfiai adatok a halászóvizek, melyek többnyire folyóvizek, azonban akadnak duzzasztással létrehozott halastavak is. A hal- és rákfogyasztás eléggé elterjedt lehetett ekkor, s ennek a böjti étkezésben is szerepe volt, ezt mutatja, hogy az összeírásokban rendszeresen felbukkanó kitétel a nagypénteki halat konyhára teljesítő bíró. A folyókat keresztező hidaknál, olykor jelentősebb forgalmú utak mentén vámot is szedtek, ez pedig az úthálózatra vonatkozóan szolgáltat adatot.

Az erdők közül a bükkösök és tölgyesek bírtak különösebb szereppel, hiszen ezekben hízhatott a falu kondája a makkoltatás során. De sertést tartottak a malmoknál is. Az erdők olykor „villongás”, azaz határvita alatt állnak két szomszédos falu között, s ezek lezárása legtöbbször majd csak a 19. században jut nyugvópontra. Egy-egy fennmaradt határjárási jegyzőkönyv számos földrajzi adattal gazdagítja a tudásunkat. A faizás, azaz a jobbágyok erdőhasználata ebben a korban megengedi a tűzifa és épületfa szabad vágását, de megjelennek a tilalmasnak nevezett erdők is, ahol mindez tiltott. A várba karácsonyra megkövetelt egészhelyek után szekérnyi fa kivágása, behordása az urbáriumok rendes adó rovatában szereplő visszatérő adat.

Olykor a szántóföldek kapcsán megjegyzik, hogy hány nyomásban használják a határt a jobbágyok. A termesztett gabonák nem mutatnak különösebb változatosságot, az őszi (búza, rozs) és tavaszi vetésűek (árpa, zab) szinte minden falu határában megtalálhatók. Előbbi (gyakran keverten vetve) kenyérgabona, a zab pedig a lovat tartó gazdaságokat jellemzi. A zabbevétel részben a szőlőbirtokosok egy részének (az extraneusok, azaz idegenek) hegyvámjából ered. Egyes urbáriumok ritkább gabonaféléket is említenek, ilyen a tönköly (az 1570-es és 1576-os adatok szerint általánosan termesztik még), majd a tatárka (kölesmuhar), illetve a a búza és a tönköly keverékének tartott voltér. Az árpa szerepet kap a serfőzés során is (a várakban szolgáló német katonasággal szokás a serfogyasztás növekedését magyarázni), s a beszolgáltatott termények között megjelenik idővel a termesztett (vagy vadon szedett?) komló is, mintegy felváltva az 1570-es urbáriumhoz mellékelt élésmesteri utasításban még lengyel behozatalként leírt komlót.

Az adó alá eső haszonnövények között egyes falvaknál káposzta, hagyma, répa is szerepel, ezek együttesen nagyobb hasznot hozó kertkultúrára utalnak. Mint rostnövény, a feldolgozott kender is a földesúri kilenced alá esik.

4. ÖSSZEFOGLALÁS

Az uradalmak urbáriumaiból nyerhető történeti földrajzi adatok a gazdálkodó jobbágyközösségek úrbéres, emellett az uradalom saját használatú (allódiális) birtokainak határhasználatával kapcsolatosak. Miután a gazdálkodás folyamatos, az időbeli változásokat jól leírják az egyes pillanatfelvételek, ami kiterjed a jobbágynépesség számára, a mezei gazdálkodás formáira, milyenségére, a szőlőbirtokokra és az erdőhasználatra. Mindezek az urbáriumot a történeti földrajzi adatok egyik legfontosabb forrásaként jelölik ki.

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THE APPLICABILITY OF AI IN THE FIELD OF OCCUPATIONAL HEALTH AND SAFETY AND ITS ETHICAL ISSUES

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Abstract: Although software based on artificial intelligence has been around for a long time, it has taken centre stage in recent years as technology has developed and is slowly becoming part of our everyday lives. Artificial intelligence is essentially a field that deals with the development of various IT systems. These systems are capable of solving tasks in a way similar to human thinking. Artificial intelligence is currently evolving rapidly and all industries are trying to exploit its potential to increase efficiency. In our research, we will examine the legal background to the use of artificial intelligence, with a particular focus on occupational safety. The use of AI in occupational safety and health raises a number of moral and ethical issues, which we analyze in our work. We have conducted a questionnaire survey in three different industries to explore workers' views on the practical application of AI in the field of occupational safety and health.

***Keywords**: artificial intelligence, work safety, ethics, morality*

1. INTRODUCTION

The global uptake of artificial intelligence continues to grow. Statistics show that 37% of the world's companies currently use AI. But what is more indicative of the exponential growth in AI use is that nine out of the world's top ten companies will invest in AI by 2023 (Web_1). With such a technology taking off, it is essential to create the right legal environment. We believe that this is of paramount importance for the following reasons:

- We are talking about a new technology that is dividing people. A proper legal environment and regulated operation would have a big impact on public opinion and perhaps shape the views of AI sceptics.
- It is also capable of performing tasks previously performed by humans. So the question arises, if it makes a mistake and there is damage to property or personal injury, who will be responsible?
- AI works from data, so it is inevitable that it has appropriate data protection rules.

Specifically, legislation on artificial intelligence is due in the European Parliament in April 2021. The European Commission then proposed the first EU regulatory framework for artificial intelligence, called the "Artificial Intelligence Act". The EU's aim was to ensure that artificial intelligence systems operate in a transparent, safe and environmentally friendly way. Its emphasis is that AI systems should not be fully automated but supervised by humans. The AI act takes a risk-based approach and defines three risk categories, which are:

- Unacceptable risk: this includes banned artificial intelligences. These include those that could pose a threat to people's safety, livelihoods and rights.
- High risk: this includes AI systems that negatively affect security and fundamental rights. These systems are divided into two parts. One part defines AI systems found in products such as toys, aircraft, cars, medical devices or lifts. In the other, it identifies eight specific areas, including education. These are subject to registration in the EU database.
- Limited risk: focuses mainly on protecting the user. It imposes minimum transparency requirements and stresses the importance of user choice. Includes AI systems that interact with humans, such as chatbots.
- Low or minimal risk: can be used without restriction (European Parliament, 2021).

The draft was a milestone in the legal regulation of artificial intelligence, as it is very important that the use of AI is supervised and regulated. In our view, the AI act is a very good initiative, as it identifies the threats of AI, prioritises them, categorises them and takes specific measures for each category, thus reducing risks. An important element of the framework is that it puts the user and their protection first. The EU has thus taken an important step towards transparency in AI systems to encourage developers to better understand the potential risks and mitigate them at the design stage. In cases of prior checks and high risk, mandatory registration can contribute to user safety and adequate data protection. The EU has taken a leading role in bringing AI within the right legal framework through the development of the AI act, which is crucial given the rapid development and take-up of the technology. If we have already mentioned rapid development above, we could formulate as a negative the need to give priority to a continuous reaction to changes in AI, so that in the future a rapid or immediate reaction to changing technologies related to AI should also be given priority at EU level.

Since data is a key element of AI, it is important to mention the regulation of AI in the legislative background. The main regulator in this regard is the GDPR. Article 5(1)(a) states that "data shall be processed lawfully, fairly and in a transparent manner for the data subject." The GDPR thus has a particular impact on AI and developers, as especially when looking at a neural network, it is working with huge amounts of data and under the GDPR it is their responsibility to filter that data properly. The legitimate and transparent handling of data is a fundamental principle that AI systems and developers must adhere to and by demonstrating this, they can contribute to increasing user trust in AI systems. Article 22 of the GDPR deals with automated decision-making and profiling. This part of the regulation sets out a general prohibition on decision-making based solely on automated processing. This is important because it provides protection for users by requiring human intervention. Interestingly, automated decision-making is not defined in the GDPR, but profiling is. This is covered by Article 4(4) of the GDPR, which states that it is "any form of automated processing of personal data by which personal data are used to evaluate certain personal aspects relating to a natural person, in particular to analyse or predict characteristics associated with the performance at work, economic situation, health, personal preferences, interests, reliability, behaviour, location or movements of that natural person." The most important provision of the GDPR in relation to these two concepts is Article 22 (1) "The data subject shall have the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her." Article 13(2)(f) GDPR specifies that the fact of automated decision-making referred to in Article 22(1) and (4) GDPR and profiling also means that the data subject must be informed of the logic used and of the comprehensible information relating to it. It must also inform the controller of the likely consequences of automated decision-making and profiling for the data subject. Article 15(1)(h) GDPR describes specific rights of access. The GDPR thus provides users with a strong safeguard to ensure that automated technologies do not violate the user's rights and, in some cases, human dignity. The aforementioned automation and profiling also take place in the course of the operation of the AI. The current regulation under the GDPR provides, in my opinion, adequate protection for users in the area of AI-related data processing. The data protection provisions it contains are adequate to protect users. It is currently the only piece of legislation in force which, if not specifically specialised for AI, is of crucial importance for the data management tasks of AI. Its provisions are indicative and provide an appropriate framework to address data protection concerns related to AI.

There is currently no legal regulation in force in Hungary regarding artificial intelligence, but the GDPR is of course in force in Hungary. Currently, artificial intelligence is mentioned in Hungary in the following legislation and in the following aspects:

- Act XCI of 2021 on National Data Assets. The preamble of the Act deals with artificial intelligence, stating that the National Assembly believes that modern and digital government and economy can be achieved through techniques based on artificial intelligence and data analysis. They recognise that this requires the creation of an institutional framework.
- In Article 4 (1) of Act LXXVI of 2014 on Scientific Research, Development and Innovation, the Government shall establish a medium-term scientific research, development and innovation strategy, point g) of which provides for the initiation of programmes and measures to support the challenge and dissemination of artificial intelligence.
- In the Government Decision 1393/2021 (VI.24.) on the National Military Strategy of Hungary, we can find several references to artificial intelligence in the field of capability development.

In 2018, the Artificial Intelligence Coalition was established at the initiative of the then Minister of Industry and Technology, Dr. László Palkovics, in cooperation with the Ministry of Innovation and Technology, to create the Artificial Intelligence Strategy of Hungary for the period 2020-2030. The strategy recognises the rapid development of AI and the fact that it is gradually becoming part of our everyday lives. In the strategy, the government commits to "making AI Hungarian, high tech and green." and "to use it to the fullest extent to improve the living standards of citizens and protect the environment." (ITM, 2020). The strategic principle shows the government's commitment, but in our opinion it is approached too much from the innovation side. Point 4.1.6 of the strategy states: "Create an effective and supportive domestic regulatory environment and ethical framework for the operation of MI, taking into account the EU legal framework."[5]. This is already a positive step towards the development of domestic legislation, but no specifics are mentioned in the startegy. The aim is to establish a code of ethics to define human-centred use and ethical AI objectives. In our view, this is extremely insufficient. Obviously it is important to have such a code, but first and foremost legislation should be created to guarantee responsible, transparent and, at the same time, ethical AI. One of the annexes to the strategy is the Action Plan, which sets a target date of 30.06.2021 for the completion of a legal framework for AI. Of these, only the aforementioned Act XCI of 2021 on National Data Assets has been implemented, but not the framework. This could be a problem because the field of AI is evolving faster every day, which should be continuously followed by legislation. Thus, the fact that there is no draft legal regulation yet will put us at a huge disadvantage compared to the level of development of AI. In our view, the Ministry of Technology and Industry should also have a Secretary of State to deal with AI and AI-enabled technologies to respond more effectively to AI developments and the changing circumstances that come with them. We consider Hungary's Artificial Intelligence Strategy a good initiative that clearly indicates the Government's commitment to AI and the innovative solutions it provides. However, further fine-tuning and development would be needed with more specificities. The strategy alone is not sufficient to provide an appropriate regulatory framework, although it is set out as a target. In our view, the legal framework should be developed as soon as possible to ensure that the MI truly serves the interests of society, ensuring transparency in its operations and clarifying its responsibilities. The framework should allow for the responsible use of AI in both industrial and societal applications, which will enhance societal well-being.

2. MORAL AND ETHICAL ISSUES

OSH is one of the most responsible jobs because it is directly linked to the protection of human life, health and safety at work. Professionals and managers working in this field have key roles that contribute to safeguarding and improving the safety, well-being and quality of life of workers throughout the workplace. Moral and ethical issues are of paramount importance in the field of occupational safety and health, as the physical and mental safety of workers is at stake. AI systems should also pay particular attention to these issues in the field of occupational safety and health. The protection of human life and health in the workplace is a priority and the application of AI must adhere to guidelines that ensure the dignity of workers' rights. In 2018, the European Commission set up a high-level independent expert group on the ethical operation of AI, which formulated four ethical principles that must be respected for AI systems to be used reliably. The Group considers the following to be ethical requirements for AI:

- Respect for human autonomy;
- Preventing damage;
- Fairness;
- Explainability (European Commission, 2018).

The ethical requirements of the profession deal with the issue in general, but the usability of AI for occupational safety and health is a specific area where moral and ethical issues also touch on many other aspects. In considering the operation of the systems presented in Chapter 4, the key moral and ethical issues are as follows:

- Data protection;
- A question of responsibility;
- Protecting the private sphere;
- "Impersonality".

2.1. Data protection

Artificial intelligence systems deal with very large amounts of data, including trade secrets, personal data and sensitive information. Data protection is now well-regulated by the GDPR, but when using AI systems for workplace security purposes, it is essential that a comprehensive internal data protection policy and guidelines are developed and adhered to. The creation and enforcement of a data protection policy is essential for the reliable and ethical operation of OHS AI systems. Data protection should be a key consideration to ensure that the data of the business and its employees is protected and does not fall into unauthorised hands. In addition, secure data management contributes to building and maintaining employee trust in the use of AI. Maintaining high standards of data protection and data management is fundamental to the responsible and ethical use of OHS AI systems.

2.2. The question of liability

In general, we consider this to be one of the most critical areas of AI, because we are talking about systems that are capable of autonomy and autonomous decision making. This fact carries with it a serious responsibility, as it is not always clear who or what is responsible for any wrong decisions made by the AI. Unfortunately, the issue of liability is not yet legally clear, which is an additional challenge. OHS systems are based on a cooperative collaboration between the OHS professional and the OHS, whereby the OHS professional supervises and controls the operation. In this case, the issue of responsibility is simplified, as the system is under supervision and control, so the responsibility would be assigned to the OHS professional and the development company. It is essential that the question of responsibility is set out in internal rules to ensure transparency and accountability in the application of the OHSM. By establishing internal policies and assigning responsibilities, the company ensures responsible and ethical operation and increases trust in the system.

2.3. Keywords

The application of artificial intelligence in the field of occupational safety and health generates and processes a wide range of data that is linked to the privacy of workers. This can occur during OHS training, employee inspections, occupational health applications and in some cases work environment monitoring. The biggest privacy-related problem arises in the case of employee inspections, where there is actual surveillance, which also entails psychosocial risks. Privacy should be enshrined in the data protection policy, taking into account the GDPR, by specifying who has access to the data and why. Maintaining privacy protection and strict compliance with data protection regulations is key to the operation of an ethical and responsible OHS system. Adherence to such policies not only ensures compliance with data protection legislation, but also increases employee confidence and acceptance of the use of AI in the workplace. However, for this to happen, it is essential that employers communicate the policy to employees in a clear and understandable way through training.

2.4. Protecting the private sector

One of the biggest risks in the application of AI in OSH is "impersonalisation", meaning that certain tasks that have been performed by the OSH professional will be performed by the AI. At the moment, there are no studies on how this will be received by workers, so it is very difficult to say how they will react, for example, to the annual OSH training via a chatbot. We believe it is essential to consult workers in detail before introducing any kind of OHS-related AI. Detailed consultation with workers can help identify any concerns, issues and needs and can contribute to the design and implementation of OHS AI applications. Consultations allow workers to participate in decision-making, which can increase acceptance and confidence in the technology. We believe it is important to stress to workers that the OSH professional is still in charge of their professional tasks, to which the AI only "assists" and has oversight of the entire system. We believe that this will also increase the feeling of safety and the acceptance of the AI.

3. EMPLOYEE OPINIONS ON THE POTENTIAL OF USING AI IN OCCUPATIONAL SAFETY AND HEALTH IN A GIVEN COMPANY

Based on our research, there is currently no survey or research on the usability of AI for occupational health and safety and the reactions of workers to it. We believe it is important to assess the attitude of workers towards the application of AI in the field of occupational safety and health, as the technology is developing very rapidly, and we believe that it will be applied in the field of occupational safety and health in the near future. The survey was conducted anonymously using a questionnaire in three different industries. The questionnaire contains a total of 16 questions. Of these, 15 are closed questions and one is open. In the open question, comments and observations were given. Our main objective with the questionnaire survey was to explore the workers' views on the use of AI in practice in occupational safety and health.

When preparing the questionnaire, we assumed that:

- The majority of survey respondents are familiar with the concept of AI and have used AI systems;
- The 18-30 age group are the most frequent users of AI;
- The majority of respondents have never heard of the use of AI in occupational safety and health;
- The 18-30 age group is the most positive towards the use of AI for occupational safety and health and the 51+ age group the most negative;
- The majority of survey respondents do not see any risk in the use of AI for occupational safety and health;
- According to respondents, it is very important to create the right legal environment;
- The issue of liability is the biggest concern.

A total of 127 questionnaires were evaluated. In the first question, we asked for general information about the respondent, which included gender, age and job title. 55 percent of the respondents were male and 45 percent were female. In terms of occupation, 24 percent were manual workers and 76 percent were white-collar workers.

The age distribution was as follows:

- Forty-four per cent of respondents aged 18-30;
- Thirty-three percent of respondents in the 31-50 age group;
- Twenty-three percent of respondents were in the over fifty age group.

The second question aimed to find out if the participants were familiar with the concept of artificial intelligence. The result was that eighty percent of the respondents were aware of it.

The third question was "have you ever used artificial intelligence? The number of respondents who do not intend to use AI in the future is notably low. However, when broken down by age group, it can be seen that the 18-30 age group is the most widespread user of AI, with 78% of respondents having used some form of AI. This compares to 27 percent of respondents in the 31-50 age group and only 5 percent of respondents over 50.

In the fourth question, we asked those who had already used it what purpose they had done so. Based on the second question, a total of 42 people had already used AI. Most of them, 64% of respondents, have used it for entertainment purposes only, with a further 23% using it for general internet searches. Eight percent of respondents indicated that they had used it as a digital assistant, with another five percent for art or product design. Based on the responses given, the low number of digital assistants used surprised us the most, given that applications such as Apple's Siri and Google Assistant are very common. We attribute the low response rate to the fact that users are probably not well informed by developers about how the applications work, and are therefore not aware that they are based on artificial intelligence.

In the fifth question, respondents were asked to select from existing AI applications those they had heard of. This information was used to explore the level of knowledge respondents had on the subject. For this question, several options were given.

Most respondents are familiar with Chat GPT and Bing AI. Chat GPT is one of the most popular and widely used AI-based chatbots. It is also very much in the media, so it is not surprising that it is the most well-known among respondents. Bing AI is the artificial intelligence of the Microsoft Edge web browser. It is immediately visible when you enter the browser, so it is the second best known behind Chat GPT. The other AIs listed are not so widely used, so it is not surprising that few people are aware of them. There were only two respondents who had not heard of any of them.

The sixth question is closely linked to the fifth question. Here, we wanted to know which of the ones they were familiar with had been used. To get an overall picture, it was also necessary here to tick more than one answer. Starting from the fifth question, the answers were not surprising. 91% of survey respondents had already used Chat GPT and 68% had used Bing AI. Discord and Midjourney were also used by two. Google Bardot and Canva were used by none.

The seventh question asked whether respondents had heard of the use of AI in occupational safety and health. 97% of respondents had not heard of it and only 3% had heard of it to some extent. This is not at all surprising, given that AI has not yet taken off in the field of OSH. Unfortunately, those who had heard of it did not respond to the question on comments and observations, although we would have been very interested to know which areas they had heard of. In our opinion, it could be a topic related to the monitoring of workers, since, for example, the monitoring of rest periods by artificial intelligence is already widespread abroad and has been repeatedly reported in the media.

The eighth question was "In which area of occupational safety could you imagine the application of artificial intelligence?" Several options were available to the respondent for this question.

Most of the respondents could envisage the use of AI in the field of OSH training. The reason for this is that the most common AI is chatbots and the way they work is something that respondents can think of in relation to OHS training and general OHS information. In relation to OSH inspections, respondents presumably associated this with the inspection of personal protective equipment. The fact that 41 of the respondents indicated that they could not envisage its application in any area is also an important observation, as it shows that there is some scepticism or uncertainty about the potential for the application of AI in the field of OSH. This points to the fact that addressing such uncertainty will be a major challenge for future AI applications.

In the ninth question, we asked how employees felt about the potential use of AI in their workplace, in the context of occupational safety and health. For this question, only one answer could be marked

For us, of all the questions asked, we were most surprised by the results of the answers. We believe that AI has become a very divisive social issue at its core, and in light of this, we expected divisions in the application of AI in OHS. We were extremely surprised that many respondents were neutral on the topic. On closer examination, we concluded that this may be because people are not yet familiar with OSH specifically, as it is not yet widespread and is applied in a very small area. They foresee its spread in the distant future and thus do not yet attribute to it an impact on their work. Another interesting finding is that the difference between positive and negative feelings among respondents is relatively small. People do not yet have a mature opinion on the application of AI in occupational safety and health and it will therefore be important to monitor its development and people's reactions in the future.

The tenth question was: 'Please indicate on the scale below how much you think the use of artificial intelligence could improve the effectiveness of OHS activities? (-5 significantly decreases efficiency, +5 significantly increases efficiency)" For this question, respondents were also only allowed to mark one answer.

The most common response, based on the ratings, was 0, indicating that the majority of respondents believe that the effectiveness of OSH activities is not affected by MI. Based on the responses to question 9, the result is not surprising and the reason is as explained there. The second most frequent answers were +2 and +3, indicating a positive effect. This means that the majority of people expect a positive or slightly positive impact from the use of AI. However, there are also some negative ratings (-5, -2, -4), but these are much lower, indicating that few people think that it would significantly reduce the effectiveness of MI. Overall, the majority of respondents do not see that MI would significantly worsen or improve OSH.

In the eleventh question, we wanted to find out what the respondents thought the benefits of using AI in occupational safety could be. For this question, several options were available (Figure 1.).

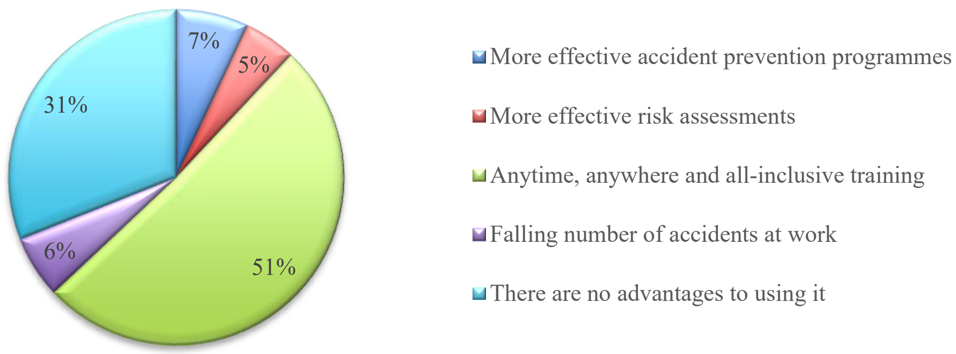

Figure 1
Benefits of using AI in occupational safety and health according to workers' perceptions

The largest percentage of respondents indicated that education is available at any time and is all-inclusive. We also see the reason for this in chatbots, because they are equated with the way education works. A small proportion of respondents thought that this would make risk assessments or accident prevention programmes more effective and that the use of AI would reduce accidents at work. Unfortunately, 31% believed that there were no benefits to using it. Understanding and reformulating this requires further analysis and action for the future.

In the twelfth question, we asked respondents about their concerns regarding the use of artificial intelligence in the field of occupational health and safety. In order to get a complex picture, we allowed for the marking of several response options.

Responses were very mixed on concerns. Survey respondents were most concerned about technical flaws in AI. The responses also show that many people have privacy concerns, which makes it crucial to have a comprehensive privacy policy. The issue of replacing humans with machines is also an important factor, which was also identified by many respondents. Because of the complexity of this issue, it was considered important to look at how many people identified two or more possible answers. As a result, 25 percent of respondents selected two or more options. This again indicates that consultation and education with employees before implementing any AI system is extremely important in order to gain a better understanding of its operation and thus a more accepting attitude.

In the thirteenth question, we looked at the risks to occupational safety and health that workers perceived to be posed by the exclusion of human factors. Also due to the complexity, several answer options could be marked. As shown in Figure 2., each of the risk sources received a high number of marks, indicating that respondents perceive risks in the use of AI. Only 9 respondents consider that there are no risks from its use, all of them in the 18-30 age group. This may suggest that this age group is more familiar with AI technology and therefore more accepting of the topic and sees less risk.

In the fourteenth question, we asked respondents how important it is for AI to operate within an appropriate legal framework (Figure 3.).

Figure 2
Risks of human factor exclusion based on workers' perceptions

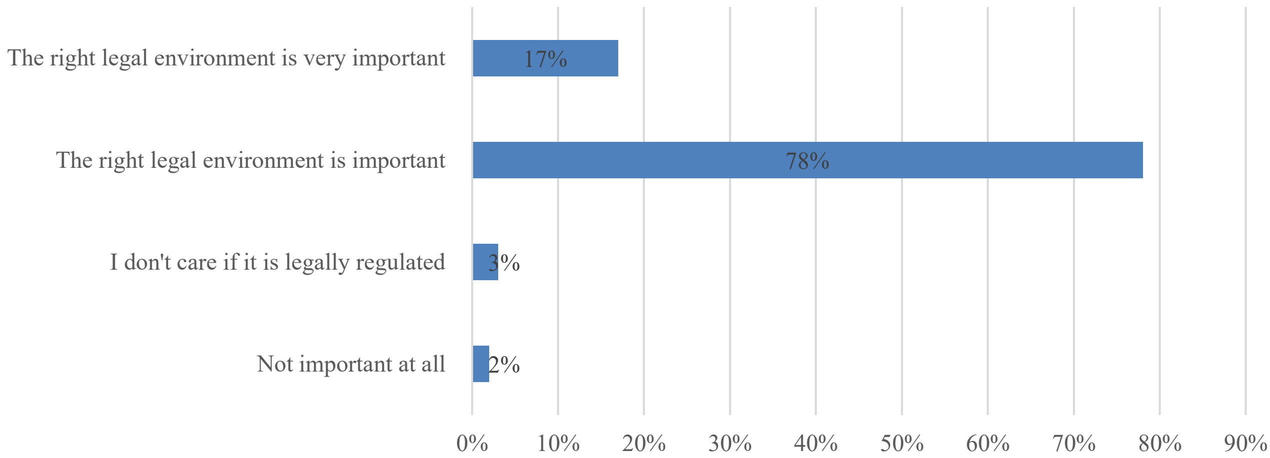

Figure 3
Employee perceptions of the importance of the legal framework for AI (edited by the author)

A large majority of respondents, 95 percent, consider an appropriate legal framework for the use of AI to be important, indicating that workers are aware of the challenges and risks associated with the use of AI and believe that legal regulation is needed to ensure the safety and effectiveness of AI use (Figure 4.).

In question fifteen, we examined the moral and ethical implications of the use of artificial intelligence in occupational safety and health. The question was "Taking into account the ethical and moral issues, what concerns do you have about the potential use of artificial intelligence in the field of occupational safety and health?" For this question, only one answer could be marked.

The responses to the moral and ethical issues were split, indicating that all of these factors need to be taken into account when designing and implementing AI systems. The 'impersonal' issue stands out, suggesting that, on moral and ethical grounds, workers would still be concerned at present about having a 'machine' perform part of the tasks of an OSH professional. To mitigate this, we believe it is important to provide adequate training and information for workers, as well as interactive programmes to demonstrate the potential of artificial intelligence. The issue of responsibility is a concern for 29% of respondents. Privacy and data protection were also cited as concerns by many respondents. This also suggests that it is crucial to have a detailed, comprehensive privacy policy, which should clearly define data handling and responsibilities for AI systems.

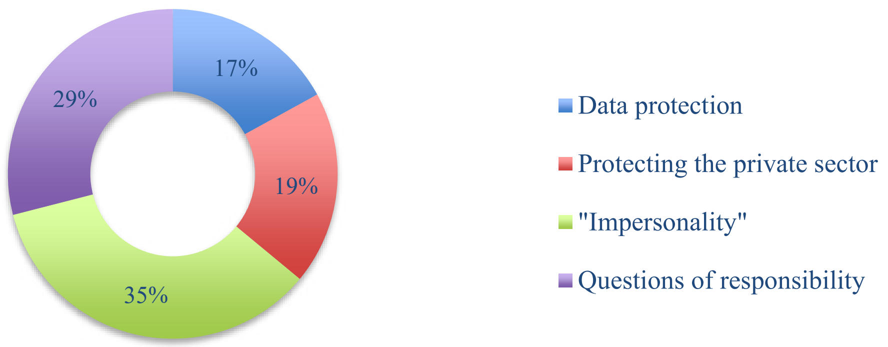

Figure 4
Moral and ethical concerns as assessed by employee perceptions

The sixteenth question was an open-ended question in which survey participants were given the opportunity to comment or make observations on the usability of AI for OHS. Unfortunately, no one answered this question.

The survey results show that respondents are strongly divided on the use of AI in the field of occupational safety and health. It can be seen that younger age groups who are familiar with and use AI see more potential for its application in OSH. They have some concerns about its use in the field of OSH, but at the same time they see it as a positive and an opportunity. The development of an appropriate legal framework and ethical guidelines is important to ensure that workers trust the use of AI. These findings suggest that workers are currently sceptical but may be willing to accept AI in the workplace environment if the right conditions are in place.

4. SUMMARY

Artificial intelligence is not a new technology, with a history going back nearly 70 years. However, it has evolved rapidly over the last decade and as a result has become part of our everyday lives. Companies are trying to exploit its potential in order to increase their efficiency. As a result, the artificial intelligence market has become highly competitive, leading to a rapid development of the technology. Its use is not yet widespread in the field of occupational safety and health. Based on our questionnaire research, workers' opinions are still divided on the use of AI in occupational safety and they foresee several concerns. For this reason, we believe it is crucial to create a detailed legal environment and internal regulations for employers as soon as possible, both in terms of data protection and ethical and moral issues, in order to increase workers' trust in AI.

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Web_1: https://dataprot.net/statistics/ai-statistics/ Downloaded on: 2023.09.02

SAFETY ASPECTS OF SERVICING ELECTRIC CARS

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Abstract: The e-mobility revolution and its social diffusion are limited by the 200 km range on a single charge, but it must be admitted that people rarely need to go more than that in their daily use. Potential users who choose this transport alternative are already likely to be using solar or geothermal energy to power their homes, and thus charging their electric cars with environmentally friendly renewable energy. However, the majority of electric cars do not pollute on the roads, but during their production and charging, if the energy for e-cars is not obtained from renewable energy, only the location of CO_2 production changes. Electric propulsion of vehicles has a decades-long history and a substantial market penetration in recent years, which requires new technical solutions for their maintenance and servicing, for which many existing service stations are not yet prepared. In recent years, almost all car manufacturers have launched pure electric cars. Although the share of electric vehicles in the overall vehicle fleet is still small, repair shops must be prepared for the increasing number of electric vehicles that will need to be inspected or repaired in the future, because the basic maintenance strategies used have changed with the uptake of electric drive. There are a number of risks involved in servicing electric vehicles, and we have summarised these risks in our work.

Keywords: *electric cars, work safety, hazardous workplaces*

1. LEGAL AND MANUFACTURING BACKGROUND

Sales of electric vehicles have grown exponentially due to falling costs, developing technology and government support. In many countries, governments are providing legal incentives to encourage the uptake of electric vehicles, including licensed bus lane use, tax breaks, free charging points, free ferry water transport and free parking. Norway, Iceland, Sweden, the Netherlands and China are switching to electric vehicles at an impressive rate, and are in the top 5 countries with the highest proportion of electric vehicle sales. Strong government policies and financial incentives in these countries have paved the way for dynamic electric vehicle sales growth.

State legislatures will have a major role to play in the uptake of electric technology, as environmental targets and tightening emission quotas cannot be met without electrification of road transport. Many countries plan to ban the sale of vehicles with internal combustion engines in the coming decades.

In order to comply with the EU Directive 2014/94/EU on the deployment of alternative fuels infrastructure and transposed into national legislation by the Hungarian Parliament and Council Regulation 243/2019 (X.22The Regulation stipulates the method and conditions for charging electric vehicles, the requirements for the vehicle charging service and the charging power of the charging point (3.7-22 kW). According to the Regulation, public electric charging points must, without exception, be equipped with a three-phase type 2 plug-in socket (Figure 1), which complies with the standard MSZ EN-62196-2 and provides a charging power of 43 kW (400 V, 63 A) at the charging station. If high power charging is also possible, the presence of 1 combined connector (Figure 1) according to EN 62196-3 is required, which adds two additional electrical contacts to the type 2 connector. The combined connector for fast charging supports AC and DC charging with a maximum charging power of 170 kW (2014/94/EU; Web_1).

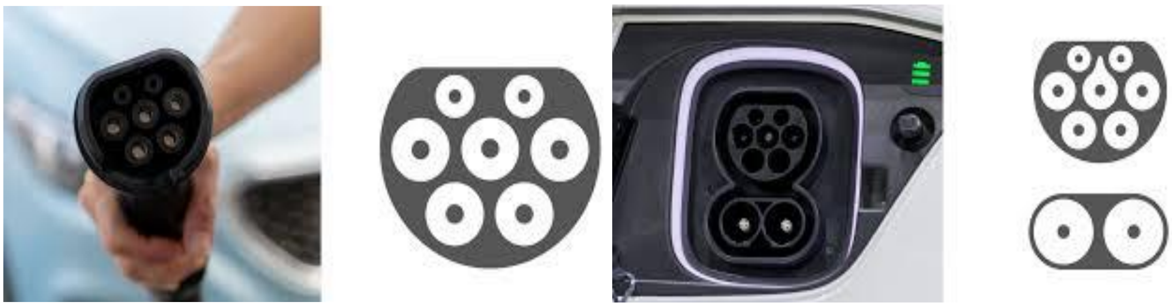

Figure 1
Type 2 connector on the left, combined connector on the right (Web_2)

According to the MEKH report, in 2022 a total of 7.1 GWh of energy was charged into electric cars from public electric charging stations, but this is not the total amount used to charge electric vehicles in Hungary, because the amount of energy used for household charging is not included in the statistics. The increased risk of electric shocks when charging electric cars is highlighted by the NFM Decree 40/2015 (30.VI.) amending the Decree 6/1990 (IV. 12.) of the Ministry of Economy and Labour, which, in addition to a kind of standardisation of electric cars, also helps to identify them.

According to the Decree No 5/1990 (IV.12.) on the technical inspection of road vehicles, the owner of all electrically powered vehicles must have a test of contact protection before the technical inspection. This is necessary in order to avoid the risk of electric shock and to prevent the occurrence of an electrical fault. The contact protection test shall include the testing of the connection cable, its immunity to damage, continuity and insulation resistance measurements and IP protection. For many years, there has been disagreement between many service and technical test centres as to whether or not a contact hazard test is required when testing pure electric cars. The uncertainty was caused by the fact that according to § 9 (3) of the Decree No. 6/1990 (IV.12.) of the Ministry of Transport, Building and Urban Affairs on the technical conditions for the registration and operation of road vehicles, vehicles with electric propulsion and electric equipment must comply with the relevant contact protection requirements, which many test centres have applied to trolleybuses in the past, so that many of them have refrained from such testing of electric cars in order not to impose extra costs on the owners.

In addition to strict adherence to general regulations, manufacturers are constantly striving to improve safety to gain the trust of their customers. To avoid a fire or electric shock caused by a collision accident, manufacturers have designed electric cars so that the car de-energises itself in the event of a collision.

The manufacturer draws attention to the risk of electric shock by marking the high-voltage wiring of electric cars in orange. Charging instructions regulate the optimum charging time for both slow and fast charging and draw attention to the risk of overcharging explosion. But it is not only the occupants of cars who need to reduce the risks, manufacturers also need to reduce the risks to those who maintain the vehicle or to firefighters who intervene in the event of an accident (Vajda, 2018; NFPA, 2010).

2. MAIN PRINCIPLES OF ELECTRIC VEHICLE DESIGN

Manufacturers are trying to take advantage of the operationally favourable external characteristics of electric motors. The structural design of an electric car is highly dependent on the electric motor used, so a generally understandable design is presented here.

Electric propulsion can be divided into three subsystems:

- drive train (control and conversion unit, electric motor, mechanical drive),
- energy source,
- auxiliary equipment (Erjavec, 2013).

You can already see the difference in the electric vehicle's design by looking at the powertrain and the motors used to power it, but the big contrast is the large Li-ion batteries that replace the fuel tanks and provide the electrical energy.

The weakest point of electric cars is undoubtedly the lithium-ion battery, which is degrading year by year. This is a phenomenon known to engineers, with degradation rates ranging from 1 to 4% per year. The composition and energy density of lithium-ion batteries are constantly improving and the component is becoming more durable. This is reflected in the fact that car manufacturers have increased the original 5-year battery warranty to 8 years. Experience shows that cars built 10 years ago have a reduced range, but are still in use today with a battery condition of around 60-80% (Gyarmati and Zentay, 2017).

3. CLASSIFICATION OF E-CARS BY BATTERY SIZE

Hybrid electric car

HEV (Hybrid electric vehicle): contains a small electric battery to supplement the internal combustion engine. The battery is recharged by the petrol engine and braking energy.

Rechargeable electric car

PHEV (Plug-in hybrid electric vehicle): contains a larger battery than a hybrid car and is charged directly from the mains.

Electric car with extended range

EREV (Extended range electric vehicle): powered by an electric motor, but when the battery is discharged the electric generator is powered by an internal combustion engine.

Battery electric car

BEV (Battery electric vehicle): no internal combustion engine, the large battery can be charged from the mains.

Fuel cell electric car

FCEV (Fuel cell electric vehicle): a fuel cell consisting of oxygen and hydrogen replaces the battery, the hydrogen is pushed through a platinum catalyst and splits into two ions and an electron, the electron drives the engine and the hydrogen mixed with oxygen escapes as vapour.

4. HIGH-VOLTAGE COMPONENTS IN ELECTRIC CARS

Power electronics

It converts the high voltage into a low voltage for the 12 V mains, and also converts the DC voltage from the high voltage battery into AC voltage for the electric machine and vice versa for charging the battery.

High voltage battery

The high-voltage system container, containing the battery control electronics and the maintenance connector.

Electric machine

An alternating current synchronous machine that drives the vehicle, starts the internal combustion engine and charges the high-voltage battery as a generator and the 12 V battery via the power electronics.

Air conditioning compressor

It is driven by high voltage and connected to power electronics.

High voltage cables

Large cross-section wires marked in orange connect the high-voltage components.

- One wire connects the power electronics to the air compressor (266 V DC);
- Two wires connect the high-voltage battery to the power electronics (266 V DC);
- Three wires connect the power electronics to the electric machine (300 V AC).

5. ELECTRIC CAR SERVICING

Whether it's a conventional or electric car, there is no difference in the wear and tear on the running gear, wiper blades, tyres. In the same way, the running gear and braking system of an electric vehicle should be checked at regular intervals. The pollen filter and brake fluid should also be changed during servicing. The coolant plays an important role in cooling the components of electric cars and should be changed every 120,000 km.

Electric cars generally use three-phase AC synchronous motors that contain no wearing parts, so the motors themselves require almost no maintenance. But there are other parts that do require maintenance or inspection, such as brakes, although these also need to be replaced less frequently because electric vehicles use brakes less. One reason for this is the recuperation process described above, whereby kinetic energy is converted into electrical energy when the car is braked, so that it can be recovered. Recuperation also acts as a kind of engine brake, reducing the strain on the braking system so that it does not wear out as quickly as an internal combustion engine. In addition to a large Li-ion battery, electric cars also include a conventional lead-acid 12 V secondary on-board battery, which is needed to power the same components as conventional internal combustion cars, such as wipers, lights, radio and dashboard, in addition to the large capacity lithium-ion battery. Also, when switched off, the high-voltage battery is disconnected for safety reasons, so that the 12 V battery is used to power the system. The electric car does not need to have its engine oil and oil filter, air filter, petrol or diesel filter changed, nor does it need a spark plug or glow plug, as these are not included.

A special component on the maintenance list is the large battery, which is often checked visually. As part of the general maintenance, the charging connection and cable connections on the one hand, and the condition of the battery on the other, are thoroughly inspected (Web_3, Web_4, IDIS Consortium, 2021).

5.1. Maintenance tasks

We've put together the 5 most important service tasks to perform on an electric car. These include subtasks such as checking wiper blades, washer fluids and vehicle lighting.

Battery check

During regular servicing, the temperature control system and the cells should be checked for proper operation and the coolant replaced if necessary. If the battery is faulty, the module should also be replaced.

Checking the chassis

During regular servicing, the steering gears, linkages, tyres and running gear are checked.

Checking wheels and tyres

The air pressure and tread groove depth are checked. If it drops below 2 mm for summer tyres and 4 mm for winter tyres, the tyre should be replaced as it may compromise safe driving.

Brake system and brake fluid check

I have already described the regenerative braking system and its long life, but these are also checked during regular service and the brake fluid is changed.

Cabin air filter replacement

The active charcoal or bionic cabin filter filters the air entering the cabin, which is often clogged with dirt and dust. Their replacement interval is the same as the service interval, so they are replaced at each regular service (Web_5).

5.2. Qualifications and proposed tools for servicing

Most mechanics have already encountered electric (BEV) or hybrid (HEV, PHEV) cars. Servicing these types of vehicles poses a risk to the mechanic because of the high voltage system in the vehicle. In order to avoid accidents, it is important that they are serviced only by qualified persons who are obliged to follow the procedures and relevant safety standards set by the manufacturer (e.g. ISO EN 50110- 2:2011). As the traction batteries of electric cars are industrial batteries and have a voltage between 100 and 400 V, servicing should only be carried out by persons trained in high voltage.

Qualification levels

- Unqualified person: all persons not employed by the workshop, from the driver who arrives with the vehicle to the supplier of the parts for the repair, are considered as unqualified persons for the purpose of servicing. This is because it is impossible to determine what knowledge these people have of electrical hazards or the operation of a high voltage system. Unqualified persons must be prevented from accessing the vehicle in the workshop premises and the electrical work area.
- Electro-technically trained person - EiP, EuP: The basic high-voltage training must be given to everyone who works in such a service, from car washers to tyre changers. This means that workers are aware of the dangers they face, most notably thick, orange, high-voltage cables and 400 V DC, and are aware of the hazards on the vehicle, the personal protective equipment available, the markings on high-voltage components and the principles of first aid. The qualified person may carry out repair and maintenance work on the vehicle in a de-energised state which is not related to the high voltage system, e.g. wheel replacement, repair of systems not related to high voltage (replacement of lights), but must be aware of the scope of activities that can be carried out.
- High Voltage Technician - HVT, FHV: A High Voltage Technician is already qualified and familiar with the construction of high voltage systems. This qualification allows for HVT:
  - high-voltage vehicle detection,
  - documented de-energising,
  - documented re-commissioning,
  - to carry out an insulation resistance check,
  - entitles you to work on high-voltage vehicles at non-active high voltage.
- High Voltage Expert - HVE: A high voltage expert who can already intervene in the high voltage system. The experts who can already touch the battery itself, dismantle it and replace the components and modules that can be replaced. The high-voltage expert certificate clearly states the entitlement:
  - to perform a documented de-energisation,
  - for high-voltage potential equalisation,
  - high-voltage system for insurance,
  - high voltage battery diagnostics and repair,
  - packaging and transport of damaged high-voltage battery components.

Ensuring that staff are adequately trained will allow risks to be minimised and work to be managed efficiently, with a range of specialised staff required to service electric vehicles with high voltage systems (Web_6).

As mentioned earlier, Germany already has a specific regulation governing the qualifications required to repair electric vehicles, which the Volkswagen Group has transposed with its electric car qualification regulations. However, there is also legislation in Hungary, which does not only provide for a specific qualification for the repair of electric vehicles, but also contains uniform requirements for the personnel and material conditions for vehicle maintenance. This legislation is Decree 1/1990 (IX. 29.) KHVM, which regulates the qualifications required in Hungary for the repair of hybrid and pure electric drive systems. According to the Regulation, higher and secondary vocational qualifications are required to carry out this work:

- electric vehicle propulsion engineer,
- a qualified electrical engineer,
- electrical plant engineer,
- electrical machinery and equipment technician.

However, we believe that, based on the training themes, the specialised higher engineers and specialised engineers in the field of electric vehicles are qualified to manufacture, develop and design electric drive train vehicles, not to service and repair them.

In addition to the statutory qualifications, the Regulation also allows for the carrying out of a service task related to the repair of hybrid and pure electric drive systems, subject to the training or qualification specified in the qualification regulations issued by the manufacturer of the electric vehicle fitted with the drive system to be repaired.

We have prepared an educational guide with the most important aspects and information to be covered in a high-voltage basic training course:

- Not all maintenance work requires the high-voltage system to be de-energised.
- An electrically trained person (EuP) can carry out basic maintenance work on a de-energised high-voltage system (e.g. rubber replacement, bulb replacement).
- EuP is the minimum qualification required for servicing high voltage vehicles.
- No unqualified person may work on such a vehicle.
- For work on a high voltage system, the high voltage system of the vehicle must be de-energised by the high voltage technician in a documented manner.
- De-energising and servicing of the high voltage component can only be carried out by HVT and HVE.
- The vehicle must be marked by the PDB/HVT with various warning signs.
- High-voltage lines are orange and have a large cross-section.
- The condition of the high-voltage cable can only be checked by eye, if the high-voltage cable is damaged, the HVT must be informed.
- The high-voltage system can be energised for up to 5 minutes after it is switched off.
- The way to switch off the high voltage system is manufacturer specific.
- Never assume that an electric car is de-energised just because it is silent.
- Do not touch, cut or open orange high-voltage wires or high-voltage components.
- Do not apply any force that could cause cable damage.
- Electrolyte can be flammable and toxic and can be harmful to human tissues.
- Do not carry metal objects or jewellery while working on the battery.
- Avoid exposing the EV battery to high heat, for example by not leaving it outside for long periods in hot sun and by not using an open flame in its environment.
- Do not inhale vapours, fumes or gases emitted from the battery.
- Avoid contact of battery contents with skin or eyes.

- Wear protective equipment in accordance with the personal protective equipment allowance scheme.
- In case of an accident or if you feel unwell, seek medical advice immediately.
- Only isolate and dismantle EV vehicle systems in a well-ventilated area.
- Do not release harmful substances in the battery into the environment.
- Always follow any additional instructions issued by the vehicle manufacturer.
- The EV battery is very heavy, so when lifting it, a special battery lift must be used.
- There is a risk of heat build-up, fire or gas leakage if lithium-ion batteries are misused or seriously damaged.
- Never touch the positive pole to the negative pole, and never connect the cell cover to an electrical conductor.
- Never lean on, place tools on, bend or break high-voltage wires or connectors.
- Never use a cutting tool with a sharp edge near a high-voltage component.
- Never boil, scald, heat or use hot air.
- The high-voltage power supply and the high-voltage battery of a vehicle are dangerous and can cause burns and other injuries or fatal electric shocks.
- It is forbidden for a person to work on a high-voltage system who has electronic/medical life support and health support equipment in or on his body, this includes life support equipment:
  - internal analgesic dispenser,
  - an implanted defibrillator,
  - heart rate regulator,
  - insulin delivery,
  - brain function regulator,
  - hearing aid.

Proposed installation of an electrical workshop

- Rescue hook;
- Electrically insulating carpet;
- First aid equipment;
- Eye wash;
- Insulated instruments.
- Laser infrared thermometer;
- Digital padlock catcher;
- Two-contact voltage tester;
- Digital multimeter;
- Insulated tools;
- Electrical insulation tape and cable ties.

6. PERSONAL PROTECTIVE EQUIPMENT FOR SERVICING

The specific hazards arising from the use of high-voltage systems can be eliminated by appropriate protective measures. The most commonly used basic personal protective equipment is electrically insulating protective gloves, face shields, insulating protective boots (Table 1).

All electric car repairers must have special protective equipment with the required insulation properties, the condition and tightness of which must be checked before starting work. Insulating protective equipment is essential when carrying out the high voltage system deactivation (de-energising) procedure. After de-energising the high-voltage system and checking the de-energising of the high-voltage circuit, certain service work may be carried out without insulated protective equipment, unless the work (e.g. battery replacement) involves a high-voltage component of the drive. Repair and disassembly of this part requires an insulated protective device even after deactivation.

Table 1
High voltage technician and expert EVE allowance scheme

Job title	Workflow	Personal protective equipment Name	Relevant standard	Category
High voltage technician and expert	Electric car repair (de-energizing, battery module repair)	Headgear helmet	MSZ EN 13911	HRC 3
		Electrician's helmet	MSZ EN 50365 MSZ EN 397	0
		Electrician's face shield	MSZ EN 166 MSZ EN 170	8 B
		Electrical insulating protective gloves	MSZ EN 60903	0
		Insulating protective boots	MSZ EN 20344 MSZ EN 20345 MSZ EN 50321	SB 0
		Workwear	MSZ EN 11611 MSZ EN 11612 MSZ EN 1149-5 MSZ EN 61482-2	1st grade

All electric car repairers must have special protective equipment with the required insulation properties, the condition and tightness of which must be checked before starting work. Insulating protective equipment is essential when carrying out the high voltage system deactivation (de-energising) procedure. After de-energising the high-voltage system and checking the de-energising of the high-voltage circuit, certain service work may be carried out without insulated protective equipment, unless the work (e.g. battery replacement) involves a high-voltage component of the drive. Repair and disassembly of this part requires an insulated protective device even after deactivation.

Arc helmet, electrician's helmet and face shield

Essential personal protective equipment for electric car repair includes the electrician's helmet suitable for use in low-voltage electrical installations, according to the standard MSZ EN 50365:2002, with a fully enclosed helmet frame, an electrician's face shield with Class 2 short-circuit arc (8) and ultraviolet filter (B), and a face shield with a face shield for the face, which can be attached to the helmet (Table 2).

Table 2
Requirements for helmet, harness and face protection

Headgear helmet	MSZ EN 13911	HRC 3
Electrician's helmet	MSZ EN 50365, MSZ EN 397	0
Electrician's face shield	MSZ EN 166, MSZ EN 170	8 B

Electrical insulating protective gloves

The date of manufacture must also be indicated on the gloves used or the date of manufacture must be included in the supplementary document accompanying the gloves. Insulating latex gloves shall be visually inspected and tested for breathability (Web_7).

Table 3
Standard specifications for work gloves

Chrome insulating gloves	MSZ EN 388 MSZ EN 407	2 5 4 2 4 1 3 2 X X
Electrical insulating gloves (latex)	EN 420 MSZ EN 60903	0

Insulating protective boots

In order to be suitable for live working, insulating protective boots must comply with EN 50321 for protection against electric shock, with a value corresponding to the class of footwear (Table 4).

Table 4
Standard specifications for insulating protective boots for work

Electrician shoes	MSZ EN ISO 20344 MSZ EN ISO 20345	S1 P C
Insulating electrician protective boots	MSZ EN ISO 20344 MSZ EN ISO 20345 MSZ EN 50321	SB SRA 0

Antistatic workwear

Electric car servicing requires the wearing of antistatic work clothing that must comply with the requirements of MSZ EN ISO 11611:2015 for protective clothing for welding and similar operations, MSZ EN ISO 11612:2015 for protection against heat and flame, MSZ EN 1149-5:2018 for electrostatic properties and MSZ EN 61482-2:2009 for protection against electric arc Class 1: 4 kA (Table 5).

Table 5
Workwear requirements for work

Workwear	MSZ EN ISO 11611:2015 MSZ EN ISO 11612:2015 MSZ EN 1149-5:2018 MSZ EN 61482-2:2009	1st grade

7. HAZARDS OF E-CAR SERVICING

First, it is important to identify the specific hazards that may be present in this type of vehicle. The main hazard is the presence of equipment with voltages higher than the safe voltage, and therefore the servicing of high-voltage components requires special training (see above). Work on high-voltage systems should only be carried out by a person trained as a high-voltage technician and expert and in workshops properly equipped.

Once on the trolley jack, before starting any service work on the vehicle, the high voltage technician must check that the high voltage system is de-energised to ensure that the necessary work can be carried out without any problems. De-energising is an important step in the servicing process to avoid the risk of electric shock, which is not directly related to the voltage but basically to the strength of the current and the time it is passed through the body. Several factors influence the amount of current that passes through the human body, including perspiration, ambient humidity, contact pressure and the strength of the squeeze (Web_5, Web_7).

Table 9

Electricity hazards (own editing)

Current	Triggered phenomenon	Result
below 10 mA	repulsion	uncontrolled reaction
10-25 mA	muscle contraction	unintentional tightening of parts, stiffness spasm
25-30 mA	contraction of the chest muscles	drowning
above 30 mA	heart flutter	specialist doctor without care death

7.1. Stress relief and insulation testing

There are some service jobs that do not require the vehicle to be de-energised, such as tyre replacement, brake system maintenance or wiper replacement, but there are other high-voltage consumers and components that require maintenance or inspection and should only be inspected or repaired when de-energised for safety reasons. Disconnection of high voltage systems is mandatory for most installation operations, and insulated tools must be used for this purpose, and insulated tools must always be used when working on the drive battery, even after deactivation of the high voltage system (Web_5, Web_8).

7.2. Deactivation steps

1. After switching off the ignition, the key must be removed and placed at least 3 metres away from the vehicle.
2. Then the disconnection of the starting battery and the insulation of each pole with a protective cap must be carried out. Check that no internal or external power source, auxiliary battery, external starting aid or charging device is connected to the vehicle.
3. The third step is to remove the service connector and disconnect the manual main switch and ensure that the voltage cannot be switched back on.
4. After deactivation, the high-voltage system is still energised for 5 minutes, so after the waiting time, the system must be checked for zero potential using a multimeter suitable for checking the absence of voltage (Web_5).

The green coloured aluminium padlock shown in the Figure 2 is not the safety exclusion padlock used in LOTO systems and does not contain any signage or lettering. It also increases the risk if the work area around the electric car is not isolated. LOTO is short for Lock out - Tag out, which means lock out. The idea is to physically prevent accidental switching on and off during industrial maintenance and repair by mechanical exclusion.

7.3. Lifting an electric car

In electric cars, the orange cable is used as a standard for systems above 50 V and for cables connecting high-voltage consumers. The high voltage system is still energised for 5 minutes after the ignition is switched off, because the high voltage capacitor of the inverter may be charged, so the mandatory waiting period for discharge must be waited for, and therefore servicing of the vehicle cannot commence until then. After complete de-energising, the vehicle's instrument panel and the 'ready' sign will go dark.

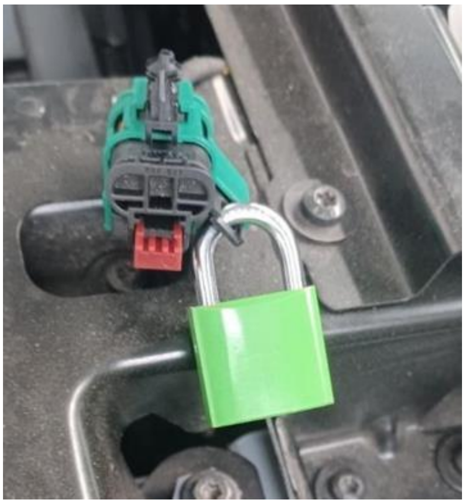

Figure 2
Back-up protection

Knowing the insulation resistance of high-voltage cables is extremely important, as at such high power levels, even the smallest insulation fault can be fatal. Insulation resistance measurements should be carried out periodically, but immediately in the event of body damage resulting from a road traffic collision. The insulation resistance measurement is performed between the inner core of the high voltage cable and the bodywork, which acts as a body point, and essentially provides the value of the contact resistance between the two points (Web_8).

Once the electric car is de-energised, the lifting process can begin. The lifting machines used in the service are subject to the Lifting Machinery Safety Regulations (hereinafter: LSA) of Decree 47/1999 (VIII.4) of the GM, therefore their installation, periodic inspections and maintenance must be carried out in accordance with the LSA and the relevant standards (MSZ 9750:2009) and the lifting machine logbook must be kept up to date. The lifting equipment must be operated only by an authorised person (lifting machine operator).

If the car needs to be lifted with the workshop jack, the first step is to put the car in a stable position by engaging the parking brake and putting the gearbox in "P". Before lifting the workshop jack, visually check that the threads are lubricated and free of dirt. During lifting, no persons shall be in the vehicle to be lifted or in the immediate vicinity of the vehicle. When lifting the car (Figure 29), it is important that the lifting is carried out at the points provided on the underside of the car bodywork so that the car cannot slide off the jack. Two lifting points are provided on each side of each car at the factory.

When the electric car is lifted, the high-voltage battery pack is located at the bottom (Figure 30) and is held to the body by a number of screws. To lift the battery pack, a special battery lifting and lowering device is also required, which must be capable of lifting and lowering a 300-700 kg high voltage battery and comply with the standards MSZ EN 1494 and MSZ EN 1493. In the case of mobile battery hoists, it must be ensured that the hoist stands on a firm, level and non-slippery, non-sloping surface during lifting. Objects must not be placed between the ground and the jack or between the jack and the vehicle lifting point (Web_9).

7.4. Dangers of battery packs

Overcharging: overcharging increases the risk of failure because it causes lithium to precipitate on the anode and carbon dioxide gas to be produced by the cathode, causing the internal pressure to increase, causing the casing to crack, and then the moisture in the air to react with the lithium and ignite the battery.

Minimum and maximum terminal voltage: beyond this range, the battery will start to heat up and ignite if it reaches a critical temperature.

Full discharge: dangerous dendrite formation on the electrodes, which punctures the separator, causing a short circuit and then a fire.

Contact with a metal disk: contact with a metal disk by impact causes the flammable electrolyte to leak, which can ignite and produce toxic gases (Farkas and Takács, 2022).

Fires due to malfunction: a battery can catch fire due to fire spreading from the environment or due to overheating of the battery. In overheating, electrolyte evaporates and leaks from the battery cells.

Toxic gas release: fires in Li-ion batteries can generate intense heat and significant amounts of toxic gas and smoke. The electrolyte in a lithium-ion battery is flammable and usually contains lithium hexafluorophosphate ($LiPF_6$) or other Li salts containing fluorine (LiF-lithium fluoride) and, when overheated, the electrolyte is released from the battery cells in the form of vaporised electrolyte. Li-ion batteries emit a number of toxic substances. The electrolyte containing lithium hexafluorophosphate ($LiPF_6$) that leaks from the battery reacts with moisture in the air:

$$LiPF_6 \Rightarrow LiF + PF_5$$

$$PF_5 + H_2O \rightarrow POF_3 + 2\ HF\ LiPF_6 + H_2O \Rightarrow LiF + POF_3 + 2\ HF \qquad (1)$$

Phosphorus pentafluoride (PF_5) is a non-flammable colourless gas with a rather short life and a rather unpleasant odour, further reacting with moisture to form phosphoryl fluoride (POF_3) and hydrogen fluoride (HF). Phosphoryl fluoride (POF_3) is a colourful, pungent smelling gas that fumes slightly in air and can react with water (H_2O) to form phosphoric acid (H_3PO_4) and hydrogen fluoride (HF). Phosphoric acid (H_3PO_4) can cause severe burns and eye damage.

$$POF_3 + 3\ H_2O \Rightarrow H_3PO_4 + 3\ HF \qquad (2)$$

The release of hydrogen fluoride (HF) from lithium-ion battery fires can pose a serious risk in enclosed or semi-enclosed spaces. Hydrogen fluoride (HF) is a pungent-smelling, colourless, corrosive toxic gas that is corrosive to the respiratory tract and can be fatal if inhaled. To avoid this, battery module repairs and replacements must be carried out with care and should only be carried out by a high-voltage specialist (Farkas and Takács, 2022; Larsson et al. 2017).

Separator damage: the Li-ion battery is susceptible to external damage. Li-ion batteries are vulnerable to damage from short-circuits, increased temperature and pressure, and eventually the battery will rupture and release flammable toxic gases. A battery damaged in an accident should be placed in a so-called dry ice sarcophagus until it is ready for recycling. Such a device is not available at the site under investigation, so the damaged battery cannot be stored safely, and it is advisable to obtain such a safe storage device.

7.5. Faulty battery replacement

After removal, the battery pack must be moved to a demarcated area and information on the prohibition of charging the high-voltage battery must be placed on it.

High-voltage battery repairs are carried out at module level and can only be carried out by a high-voltage specialist in specific protective equipment. The battery pack is made up of modules, the modules are made up of cells. If a cell loses capacity or fails, the system will no longer work or will malfunction as it is part of the large whole battery pack. In such cases, it is not the whole battery that fails, but only certain parts of it, which are detected by diagnostic software.

Replacing this module will make the battery functional again. The process involves replacing the faulty module in the high-voltage battery with a new module. Before installing the new module, the module must be set to the voltage level of the other modules of the high-voltage battery. Failure to do so may cause failure of other modules or even fire.

After the battery is balanced, when the voltage level of the new module is the same as the other modules of the high voltage battery, it can be placed back into the battery pack.

The battery pack can then be moved from the demarcated area and lifted back to the lower body of the vehicle. During lifting, care must be taken to ensure that the high voltage wiring is not damaged. The work must still only be carried out by a high voltage specialist wearing the personal protective equipment described above. Insulated tools must be used for fixing and screwing back the high voltage component to the vehicle. After reconnecting the cables marked orange, the vehicle may be lowered with the jack after the covers have been replaced. When lowering the electric vehicle, care must be taken to ensure that no workers are underneath the vehicle. After the vehicle has been lowered, the electric vehicle can be re-energised. At the end of the battery module replacement procedure, an acoustic signal shall be given to indicate the end of the procedure and the vehicle may be moved from the lift to the parking area designated for vehicle transfer.

8. SUMMARY

The electric car is not a new solution, as this propulsion solution has been around for over a hundred years. However, internal combustion engines have had advantages that have made them a clear leader in the market for cars and trucks. In recent years, however, battery technology has seen significant and successful developments that have had an impact on automotive technology. In favour of electric propulsion, the market share is clearly increasing every year and in recent years more and more manufacturers have entered the market with such vehicles. Although the share of electric vehicles in the total vehicle fleet is still small, workshops should nevertheless be prepared to inspect or repair more and more electric vehicles.

To do this, we have started from the basics about electric cars. We have also defined the qualifications required to service a pure electric vehicle, the main points of basic high-voltage training, the special insulated personal protective equipment to be used during high-voltage work and the service accessories essential for maintenance. I also described the steps, demarcations, warning markings, actions and service steps to take before safe electric car repairs.

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OCCUPATIONAL SAFETY ASSESSMENT OF ARCHAEOLOGICAL INVESTIGATIONS

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Abstract: The discipline has come a long way since the early research methods, when occupational safety was still in its infancy. Article 114 of Act XCIV of 1884 Labour Law. "Every manufacturer shall be obliged to establish and maintain in his factory, at his own expense, all such facilities as, having regard to the quality of the industrial site and plant, may be necessary to ensure the health of the workers". This was the first labour protection law introduced in Hungary, but it only dealt with the protection of industrial and factory workers, not with other non-factory and industrial workers. The archaeological field work processes and activities are governed by a single set of regulations and laws that do not deal with occupational safety, so the general instructions, rules, regulations and laws in force apply in the field of occupational safety. However, in many respects, this is a specific type of work, and our work has been carried out to assess the safety factors for certain areas and types of work in archaeological excavations along these lines.

Keywords: *archaeology, hazards, EHS, occupational safety*

1. INTRODUCTION

Archaeological demolition work is not considered as manual excavation pursuant to Section 35 § (3) of Government Decree 68/2018 (IV. 9.) on the rules for the protection of cultural heritage, and pursuant to Section 22 § (5) archaeological excavation is not considered as construction activity. For this reason, the provisions of the Labour Protection Act apply to such work. Furthermore, in a work safety study carried out under the GINOP-5.3.4-16-2018-00036 project, Annex 12, Work safety risks of excavations during archaeological excavations, "The regulations for archaeological excavations are contained in a law and a government decree, which do not explicitly address work safety regulations." (Magyar Iparszövetség, 2019).

- means of access to (or near) the excavation site (vehicle),
- the workplace, working environment (excavation site):
    - environmental factors (weather),
    - the tools used for the work,
    - physical and mechanical hazards,
    - hazardous substances in contact with workers,
    - biohazards,
    - examining the job, technology and work operations.

2. TESTING PROCESS ELEMENTS

2.1. Transport to the sites by car

Workers travel to the place of work (in the county) in 5-passenger SUVs. The journey may involve the use of different types of roads, which requires different driving skills.

Potential risk:

- For motorways, motorways, main roads: other vehicles (traffic), speed and technical condition of the vehicle used;
- In the case of a dirt road, forest road, off-road: the quality of the road (if there is a road) and the technical condition of the vehicle used;
- Long distance travel in the same airspace: spread of respiratory and other infectious diseases;
- Weather conditions (snowy, wet, slippery road surfaces, poor visibility in foggy weather).

2.2. Work in extreme weather and field conditions (archaeological investigations)

Without describing all of the professional tasks in detail, we would like to describe and assess the potential risks inherent in field work processes, primarily from the point of view of occupational safety (Figure 1), but some technical details are inevitable.

Figure 1
Excavation surface (Web_1)

Fieldwalking is the term used to describe surface exploration of archaeological sites without the aid of instruments (except GPS) and the related data collection and evaluation documentation. During fieldwalking, workers carry out a surface investigation (ideally in areas not covered by vegetation) in areas affected by agricultural works, where the different soil quality (ploughed rough ground or finely dissected porous soil) makes walking and exploration difficult. Fieldwalking, surface exploration, can be carried out without a specific system for observing the ground, or in a "combing" system, where workers line up in a chain at a specific distance from each other, walking the surface, keeping the distance between them.

Potential risks:

- uneven ground - dislocation, pulling, bruising of parts of the foot (knee, ankle),
- in the case of underground animal passages, the ground can collapse, causing serious injury (broken leg),
- wet soil: soil vapour, wetlands, sudden changes in weather (falling, slipping).

To reduce the risk and avoid accidents, it is recommended to wear high-heeled, lace-up boots with non-slip soles (rigid-soled and/or steel-toed boots are uncomfortable and not adapted to the technology during field work), protected against soaking and not slipping (regardless of the season, which can be provided by the employer as workwear) and to work with care in accordance with the ground conditions, so that the risk is minimised.

Taking into account the changing weather:

- sun exposure (UV radiation, sunstroke, sunburn, skin irritation),
- wind (cold),
- all forms of precipitation (morning mist and fog, summer showers, rain, snow, ice),
- a natural phenomenon that may accompany precipitation (lightning).

In the event of lightning in open areas, compliance with the following will reduce the risk of an accident:

- If there is no shelter nearby (building, car), try to look for a point as low as possible, as lightning mainly targets higher points that are prominent in the environment, so you may not be safe under trees (especially if you are standing alone) (even if branches break off from the tree during the storm);
- Avoid staying in tall buildings (e.g. observation towers, high rises) or near protruding objects (e.g. pylons, power lines);
- Avoid proximity to water, wet surfaces with water seepage;
- If you have any electrically conductive objects (metal tools, umbrellas), put them on the ground and move away from them, as these things attract lightning;
- Do not lie or sit on the ground, because the smaller the surface area in contact with the ground, the safer it is;
- If you are in a group with several people in the field, keep at least 5 metres away from each other until it is safe to do so.

Chemical factors may be present during the field survey, for example due to pesticides previously used on agricultural land, but the risk is negligible. Such illnesses have not been documented in our research for these jobs.

Biological factors that may occur during the field survey:

- bacteria (tetanus),
- fungi (skin fungus),
- parasites (ticks),
- other infections (e.g. near landfills, sewage treatment plants).

During the fieldwork, punctures, cuts and scratches may occur, so it is absolutely necessary (according to the 3/2002 (II. 8. SzCsM-EüM joint regulation), a person designated to administer first aid and to have at least in the vehicle (mandatory by the Highway Code), but it is recommended to carry (at least) a medical kit "B" for possible minor injuries, against over-infection and even tetanus, but preferably I. The Decree 61/1999 (XII/1) of the Ministry of Health and Social Affairs on the protection of the health of workers exposed to biological agents does not include archaeological work among the occupations listed in its Annex 1, so there is no obligation to carry out a biological risk assessment for the jobs involved.

2.3. Humming, instrumental site and artefact detection, preventive excavation, archaeological demolition

The initial phase of the "real" field work is the marking out of the area, if necessary, the clearing of the land, the clearing of vegetation, which is mostly the responsibility of the investor, followed by the "humusification", which is the removal of topsoil, carried out in Hungary by a qualified machine operator (subcontractor) with the help of a copper-needle scraper under the professional supervision of an archaeologist.

Potential risks:

- proximity to machinery (risk of being hit, stress),
- noise nuisance (proximity of machinery),
- psychological stress (decision-making situation, work that requires sustained, deliberate attention, conflict situation, stress),
- hazardous substances (flammable and explosive substances).

During humming, the worker must be close to the heavy machinery, but of course out of range, but must use hand movements to guide the operator precisely, so that he is within good visibility (5-10 metres) and knows the agreed and unambiguous instruction signs. The average noise level of the machine within 1 metre is 80-85 dB, which corresponds to the intervention limit, so wearing earmuffs at the recommended distance of 5-10 metres is not mandatory. However, the use of a safety helmet is mandatory due to the possible fall of debris from the machine and the proximity of the machine. Constant concentration and attention to the movement of the machinery and staying within sight of the operators is recommended to avoid possible collisions. Rest periods are recommended to reduce psychological stress. The level of risk remaining after the area has been cleared of ammunition (or without clearance) is considered to be minimal, but increased vigilance is recommended and in the event of any suspicious device or object resembling ammunition being found in the ground, immediate stopping of the machinery and evacuation of the area is recommended, and notification of the local police (where there is no local authority notary) is required in accordance with Government Decree 142/1999 (IX. 8.).

According to Act LXIV of 2001: Instrumental site and artifact detection: aerial survey, geophysical survey of structures and objects or their remains or impressions on land and under water, artifact mapping or collection with metal detectors, geodetic survey, and any other activity carried out with instruments for the purpose of detecting archaeological sites or artifacts.

The tools used in the reconnaissance process are basically developed for non-archaeological research, but they are also well suited to this field. Examples include geophysical and geodetic instruments, metal detectors and drones (aerial photography).

Potential risks:

- transport on uneven ground with hand-held measuring instruments (falls, sprains),
- drone control while walking on uneven ground (divided attention - fall),
- injury caused by tools (abrasion, impact, cut).

2.4. Preventive exploration

Preventive excavation is "the performance of archaeological tasks (archaeological observation, trial excavation, full surface excavation) carried out under contract using the scientific method, aimed at the excavation of registered archaeological sites affected by earthworks, developments, investments."

Many of the work processes in preventive excavation and archaeological demolition are the same from an OHS point of view, so the exposures to workers were assessed together.

Potential risks:

- confined spaces - working in a pit or trench (cave-ins, falling objects, psychological stress),
- open pits, trenches (falls, falls in, falls out),
- working in a constrained posture (ergonomics - sitting, squatting, kneeling),
- work with garden and hand tools with sharp edges (cutting, physical strain, eye injury),

- exposure to personal protective equipment (safety helmet, safety goggles),
- work at height (falls, falls),
- work in special working environments (caves, landfills, sewage treatment plants) (ergonomics - poor lighting, confined spaces, risk of infection).

In the case of excavation pits and trenches, the excavated earth must be deposited on one side of the trench (also in the case of manual excavation), respecting the 0.5 m safety clearance required for the various soil structures (avoiding soil load on the trench floor, risk of collapse). The need for excavation, winterisation, preservation and backfilling must be assessed in advance for each excavation, and the technical and financial implications must be assessed (MNM, 2023).

When working in a pit or trench, it is compulsory to wear an industrial safety helmet (EN397), which:

- LD marked (resistant to lateral deformation)
- Made of ABS or HDPE,
- adjustable headset (ratchet, but at least spiked),
- with the possibility of attaching a chin strap (to make it suitable for work at height),
- possibly with interchangeable headband (hygiene),
- with neck protector attachment (suitable for use in different weather conditions).

By using a helmet, injuries to the head can be avoided. The correct use of protective equipment must be explained to all workers.

In the case of work in open pits and trenches, there is a risk of falling, falling down, falling, which the investor must avoid, taking into account the following:

For working pits, 1 row of guardrails (which cannot be replaced by a tape) is required between 0.25-1.25 m depth, or 3 rows of guardrails for depths greater than 1.25 m. Passages must also be provided at every 200 m at the entrance to the working pit (trench) and in front of the entrance to buildings and properties, with a minimum width of 0.6 m (for one-way pedestrian traffic) (if the depth below the level of the passage is greater than 1 m, the passage must be provided with a 1.0 m high double-row barrier with a footboard). If the height of the ground depot is 0,8 m, a marker or guard rail is not required on that side (Web_2).

During archaeological work, increased attention must be paid to traffic and work in the vicinity of trenches and pits. In addition, access to trenches and pits requires the use of properly constructed ladders, ramps or ladders fixed against displacement and with a load-bearing capacity appropriate to the anticipated stresses.

During excavation work, workers often work in a constrained posture, as they perform various tasks at the site where the finds are found (e.g.: written or photographic documentation, drawing, measurements, etc.). When squatting, kneeling or sitting for long periods, the use of water-resistant material (e.g.: solid foam) is recommended to avoid negative ergonomic effects and various types of illnesses (e.g.: cold and wet weather).

During manual digging, standing in front of or behind (in the plane of the digging) the person using the pick is forbidden! Adequate clearance must be maintained between operators. Do not throw tools or store them in places other than the designated storage area! Additional tools used in the course of the work - shovels, shovels, gouges, scalpels, spatulas - must always be used with due care and attention to the fact that they have edges which may cause injury. Hourly rest periods are recommended to reduce the physical strain of working in a forced posture.

In addition to working in pits and trenches, occasionally field work may be carried out in castles, churches, on higher ground, in which case scaffolding built by a specialist contractor may be used. Work on scaffolding may only be carried out in compliance with the relevant law, regulation or national standard. Before use, the scaffolding must be put into operation, a report must be drawn up and periodic inspections must be carried out during use, for example after rain or storms. In the event of a thunderstorm, the most common accompaniment of which is intense lightning, the scaffolding must be abandoned immediately. When working on the scaffolding, the use of a safety helmet is compulsory (with a chinstrap!). In all cases, work from scaffolding must be carried out with due care and caution.

Other possible workplaces are work environments that can be described as specialised (e.g. caves, landfills and sewage treatment plants), where workers may be exposed to ergonomic exposures (e.g. poor lighting conditions, forced posture), biological and chemical exposures (hazardous substances, infections).

In cave conditions, a battery-powered headlamp with sufficient brightness, provided by the employer, can reduce the risk of mechanical injuries (falls, blows to body parts) caused by poor visibility. Layered clothing reduces the risk of illness caused by temperature conditions and wearing a helmet minimises the risk of head injuries.

Workers in or around landfills and sewage treatment plants can come into contact with various infections, the risk of which can be minimised by vaccination (the same as the mandatory vaccinations required by the occupational health physician for workers in the area).

3. JOB, TECHNOLOGY, WORK OPERATION ANALYSIS

The archaeological (field) work is carried out by workers employed in the following jobs:

- archaeologist in charge of the excavation,
- archaeologist, archaeological technician, other technician, assistant archaeologist, assistant labourer.

Workers in the above jobs can be divided into 2 groups according to the exposures they are exposed to in the course of their duties. In order to determine these exposures (risks), it is necessary to know the work processes they perform, which are described in brief textual descriptions and tables. The tables show the different hazards broken down by factors.

Job title: archaeological site manager

List and description of the autonomous operations and activities to be carried out in the framework of the independent job:

- leading the excavation,
- direct employees,
- will run the project,
- and directs and supervises the work of subcontractors and machinery.

The choice of the use of individual and collective protection to reduce the identified risks during outdoor works and its on-site implementation is always the responsibility of the excavation manager.

Necessary for your work:

- occupational safety and health training,
- fire safety education,
- medical fitness test (preliminary, recurrent),
- job description,
- operating and maintenance instructions for the machines and instruments handled,
- the qualifications needed to do the job,
- preparedness,
- practice.

The risks to the archaeological site manager are summarised in Table 1.

Table 1
Examination of mechanical factors and exposures to workers

	Identifying a source of danger	Finding	Comment
1.	Mechanical risk of accident		
1.1.	risk of being hit by a motor vehicle	is	
1.2.	risk of slipping on the work area	is	
1.3.	sprain, sprain, fracture	is	
1.4.	risk of falling, stumbling or falling over	is	
1.5.	working at height	is	ruins, castles, churches
1.6.	working deep in a pit	is	
1.7.	advanced (mobile) machinery	is	rotary excavator
1.8.	sharp, pointed tools with cutting edges	is	notcher, scalpel, spakli
1.9.	flying, airborne substances	is	dust, sand (eye injury, inhalation)
1.	Ergonomic factors		
1.1.	working in a forced body position	is	(stooping, squatting, kneeling, documenting, working in confined spaces)
1.2.	Meeting	is	
1.3.	Jobs	is	
1.4.	walking, field walking	is	on uneven ground
1.	Temperature factors		
1.1.	changing weather (hot and cold)	is	in summer: on the humified surface near the soil, temperatures can reach 55°C, in winter: field trips possible at temperatures as low as -15°C if there is no snow on the ground
1.2.	wet, damp	is	all forms of precipitation can occur
1.3.	wind	is	
1.	Physical factors		
1.1.	noise (lower action threshold 80 dB-85 dB)	not typical	on average, the noise level is ~80dB within 1 meter of the machine, it is forbidden to stay within the range of the machine!
1.2.	non-ionising radiation	is	Outdoor workers are exposed to significant UV radiation from the sun
1.	Chemical factors		
1.1.	chemicals	may occur, not typical	The archaeologist in charge of the excavation does not use chemicals in his work, but he may encounter them in the soil (work area)
1.	Biological factors		
1.1.	virus	occur	COVID19
2.2.	bacteria	occur	legionella
3.3.	mushrooms	occur	
4.4.	parasites	is	tick
5.5.	risk of infection	occur	near a waste water treatment plant, near a landfill
1.	Other factors		

Identifying a source of danger		Finding	Comment
1.1.	increased psychological stress	is	
1.2.	exposure to personal protective equipment	is	head protection, safety helmet

Psychological risks: The sum of the influences on the worker at work - conflicts, work organisation, job insecurity, etc. - which affect the response to these influences, and which may be associated with stress, accidents at work, psychosomatic illnesses.

Table 2
Psychological effects on workers at work

Serial number	Psychological risk factor	Finding	Comment
1.	Taking particular responsibility for people, material values	is	
1.2.	Decision situations	yes	
1.3.	Creative intellectual work	yes	
1.4.	Working under time pressure	yes	e.g.: for excavations related to a project
1.5.	Work that requires sustained, deliberate attention	yes	
1.6.	Situations of conflict	yes	

Job titles: archaeologist, archaeological technician, other technician, assistant archaeologist, assistant

List and description of the autonomous operations and activities to be carried out in the framework of the independent job:

- manual handling of materials,
- working on the excavation surface, in excavation pits and trenches.

Necessary for your work:

- occupational safety and health training,
- fire safety education,
- medical fitness test (preliminary, recurrent),
- job description,
- operating and maintenance instructions for the machines and instruments handled,
- the qualifications needed to do the job,
- preparedness, practice.

Most of the factors and exposures faced by workers are the same as those described for the job of archaeologist in charge of excavations. There are differences in the range of mechanical hazards to be investigated and the manual handling of materials (the handling of materials is mainly associated with the risk of back and spinal injuries).

Table 3
Exposure assessment of mechanical agents and manual handling exposure

Identifying a source of danger		Finding	Comment
1.	Mechanical risk of accident		
1.8.	sharp, pointed tools with cutting edges	is	hook, scalpel, spatula, *shovel, shovel, pick
1.	Manual handling of materials		
1.1.	5 kg - 25 kg	is	moving tools, implements and artefacts

The Table 3. evaluating the manual handling tasks performed by the workers have been constructed taking into account Decree 25/1998 (XII.27.) of the Ministry of Health and Labour and Decree 78/2003 (XII. 23.) of the Ministry of Labour and Social Affairs amending it. One of the prerequisites for maintaining health at work is that the workload caused by the workload should not deviate from the optimum on a sustained basis. The workload must therefore be assessed individually for each person when assessing fitness for work, and this is currently one of the important tasks of the occupational physician.

4. SUMMARY

To reduce the risks associated with archaeological work and to avoid work-related illnesses, long trousers, long-sleeved tops (thin ventilated in summer), hats with ears (which can be winterised with inserts) and water-repellent visibility jackets with removable sleeves (with zips) are recommended in winter and summer, so that they can be worn in all seasons. It is also recommended to wear sunglasses with UV protection and to dress in layers (mainly for UV protection, but also to a lesser extent for protection against airborne particles and dust). Prolonged exposure to the sun and physical exertion can cause dehydration, so adequate hydration (protective drinks provided by the employer) is essential, and the use of sunscreen may be recommended for uncovered body parts or in case of sun allergy.

The continuous wearing of personal protective equipment (industrial safety helmet) (mostly in an environment free of natural shade) is uncomfortable and causes considerable psychological strain, which can also be alleviated by a break from work (without wearing protective equipment). To reduce the risk of possible eye injuries, helmet-mounted goggles could provide protection, but would place an additional disproportionate burden on the worker (limiting his work: humidity, frequent shifts, stress).

In view of this and the number of accidents at work in the cultural sector in Hungary in 2023 (Nemzetgazdasági Minisztérium, 2024), we do not consider it justified. The wearing of protective goggles with UV protection, independent of the helmet, which could protect the eyes against harmful physical effects, in addition to possible mechanical injuries, is also not recommended for prescription, because the constant changes in working conditions inside and outside the working pit (changes in light and visibility conditions, contamination) would also cause a disproportionate psychological strain during work and would significantly limit the work.

The natural heat dissipation through the skin (sweating) caused by physical activity and closed clothing can cause redness in different parts of the body, and in worse cases fungal infections, which can be avoided by changing the underwear in direct contact with the skin every day, by drying and ventilating the footwear regularly and by maintaining general body hygiene, and can be reduced to a minimum risk (Herman Ottó Múzeum, 2020).

When using work equipment, you must always follow the attached instructions for use and, in the case of some equipment that requires a licence(s) (metal detector, drone), only a qualified person with a licence may use it.

Work in pits and trenches (as in the US) can only be carried out under the supervision of a designated helper, so a minimum of two people is required to carry out any work. The helper-supervisor must stand at the edge of the trench to assist the trencher and cannot be called away or assigned to other tasks.

In general, there is no running water or other infrastructure (toilets, toilets) available in the area, so washing hands before meals is not possible, which poses an additional potential risk of infection that can be significantly reduced by using disinfectants, but at least wet wipes. Wearing long, closed clothing and boots all day long provides protection against parasites (ticks) and the diseases they transmit, but insect repellents and vaccination is recommended as a supplement when working in particularly infested areas, and is the responsibility of the employer (NNK, 2023).

In all cases, the work must be coordinated in such a way that it does not pose a hazard or health risk to the workers and other persons within the scope of the work. In the context of coordination, the workers concerned and their representatives for the protection of their health and safety and those in the area of work must in any event be informed of the risks and preventive measures to be taken, in particular with regard to health and safety. The main contractor under the Civil Code shall be responsible for the implementation of coordination.

In our opinion, the risk of accidents occurring during archaeological and excavation work can be minimised if the above is observed.

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THE INTERFACE BETWEEN ARTIFICIAL INTELLIGENCE AND OCCUPATIONAL SAFETY

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Abstract: The development of AI in the field of occupational health and safety can be divided into two main phases. The first phase began in the 1960s, when artificial intelligence appeared in robotics and the first robots based on machine learning, such as SRI and Shakey (Bekey, 2005), were created. This was a significant milestone, as machine learning was then more widely applied in automation. Through the use of AI, many tasks that previously required human labour were taken over by machines, reducing the risk of accidents and injuries. The second important period started in 2015, when AI became more widespread with the emergence of deep learning technologies, and AI-based systems started to appear in the field of occupational safety and health, albeit initially on a smaller scale. These systems focused mainly on ergonomic analysis, using sensors to record workers' movements and analyse the resulting data. Another area of development was AI-based monitoring of workers' use of personal protective equipment. While there are now operational AI-based occupational safety and health systems, the use of AI in this area is not yet fully developed. The aim of our work is to identify AI-based solutions that can help in the field of OSH and simplify the management of specific problem areas.

Keywords: *artificial intelligence, occupational safety, development opportunities, work safety*

1. INTRODUCTION

The first artificial intelligence (AI) program written for computers was developed in 1956 by Allen Newell, Herbert Simon and J.C. Shaw, with the aim of using the program to solve a variety of equations thought to be complex. It was in this year that the term artificial intelligence was first coined by John McCarthy at the Dartmouth Conference, attended by some of the greatest figures in computer science at the time. Because of this and his creation of the first artificial intelligence programming language, McCarthy is considered the father of artificial intelligence (Jones, 2009). Subsequently, research was mainly directed towards neural networks, which was expected to be a huge success, but this was not to be until 1986, when four research groups 're-invented' the backpropagation learning algorithm. Around the same time, the complexity of AI systems was also questioned among research groups. This is when the term "AI winter" can be coined, which refers to a period when AI research and development stagnated or declined (Russel and Norvig, 2000). The first AI International Joint Conference was convened in 1969, has been held every two years since then and has grown to become the largest conference on AI. In 1970, the first issue of the International Journal of AI was published and since then it has been ranked first among scientific journals on AI.

The heyday of machine learning dates back to the 1980s and 1990s. It was then that researchers thought that the main goal of ML should be practical solutions. The rise of data mining and the attempt to solve various statistical problems and problems with the help of ML contributed greatly to its boom (Tandon et. al, 2019). Around 2012, another major advance was made when deep learning was created from the combination of machine learning and big data. This led to numerous and spectacular changes that have an impact on our everyday lives, for example in highly accurate voice or face recognition systems (Web_1).

2. THE CONCEPT AND TECHNICAL BACKGROUND OF ARTIFICIAL INTELLIGENCE

2.1. The concept of artificial intelligence

A definition of artificial intelligence that describes exactly what it is very difficult to formulate. There is currently no consensus among experts on the exact definition and therefore no concrete definition. Perhaps the clearest colloquial description is that it is a computer system that can perform various tasks in a way similar to human thinking. However, AI is much more complex than that and thus its formulation is much more complicated. Taking a more technical approach, the Oxford Computing Dictionary defines AI as the field of computer science concerned with the creation of computer programs that solve problems requiring human intelligence (Siba, 1989). However, AI is much more than just a program, and this term is no longer appropriate, since it is not just a program, but a set of complete systems, hardware and software, working in concert to solve problems as intelligently as possible. One of the most significant differences is in the ability to learn. With the advent of artificial intelligence, it has become clear that they are much more than the programs that have appeared so far, with their rigid predefined instructions. AI algorithms are a set of mathematical formulas and various models, the combination of which allows for continuous learning and development to solve problems more efficiently. Based on the table, the other important distinction is defined as the autonomous operation of the table. This illustrates that while a program operates in a predefined and unchangeable way, and thus static, AI is able to make autonomous decisions, adapt and react to environmental changes based on input data. Its autonomous operation allows it to "think" and "act" autonomously based on data and previous experience. We believe that the most accurate definition of artificial intelligence is given by the International Dictionary of Artificial Intelligence, which states that "artificial intelligence is concerned with the development of techniques that enable computers to operate in a manner similar to an intelligent organism, similar to human thinking. The goals are varied, ranging from a 'slightly smarter' program to the development of a fully conscious, intelligent computer-based entity." (Raynor, 1999). In another approach, "The term artificial intelligence refers to man-made hardware, software, or a combination of both, that is indistinguishable from a living human being in its operation, especially in its behaviour, or is difficult to distinguish." (Fehér et al, 2020). The first part of the formulation describes AI technically well, but the second part seems to me to give it too many human characteristics. AI is not merely about 'mimicking' human behaviour, but rather about applying general principles of human reasoning to solve various tasks. Alison Cawsey takes a much broader view. "Artificial intelligence is one of the newest cross-disciplinary fields, which is a different subject for everyone and deals with the computer-based solution of tasks that require human intelligence." (Cawsey, 2002). In this formulation, we can see the importance and diversity of AI, as the author refers to it as a separate discipline. From the definition, it can be seen that Cawsey emphasises its purpose and role, the main thrust of which is to enable machines to solve tasks that previously only human intelligence was capable of. The definition of AI is described by the European Parliament on its website as "artificial intelligence refers to the human-like capabilities of machines, such as reasoning, learning, planning and creativity. It allows technology to sense its environment, deal with what it perceives, solve problems and plan its actions to achieve a specific goal. The computer not only receives data, it also processes and reacts to it. They can also modify their behaviour to some extent by analysing the effects of their previous actions and working autonomously." (Web_2). The definition given by the European Parliament is very informative and describes the essence of artificial intelligence. It appropriately highlights its comprehensive nature, its wide range of applications and its machine-like, human-like task-solving intellect. The first EU regulation on artificial intelligence deals with the definition in a separate chapter. The Regulation also underlines that no single definition is currently uniformly accepted by the scientific community. It is believed that the concept of AI is often "generalised" in that it is a computer system that exhibits capabilities similar to human intelligence. The European Commission, believing that the correct definition of AI is crucial to avoid legal problems, has created a legal definition of an AI system, which states that an AI system is a software developed using specific techniques and approaches that, for a given set of human-defined goals, generates outputs such as content, predictions, recommendations or decisions that affect the environment with which it interacts (European Parliament, 2021).

The fact that the European Union is already recognising the challenges of defining AI at the legislative level is a good illustration of the complexity of the area we are dealing with. The development of AI is rapid and multi-directional, raising issues that have profound implications for law, society and ethics. The definition set out in the AI Act provides a well-structured and very precise formulation of AI. In addition to being highly technical, it is also easy to understand, which is very important, given the diversity and dynamic development of AI, which requires clarity in order to ensure that the most important information about AI, including the definition itself, reaches as many people as possible. The definition also shows the EU's commitment to the subject and its efforts to keep pace with the rapid development of the technology. On the question of definition, we felt that the most complex research result could be obtained by asking AI itself to define itself. To do this, we called upon two AIs, Bing AI and ChatGPT. We asked them both the same question, which was "How would you define AI?"

Bing AI gave a rather simple answer, practically "copying" the wording from Wikipedia and youth.europe.eu: "Artificial intelligence is a discipline concerned with the development of algorithms and machines that exhibit intelligent behaviour. AI generally refers to intelligence manifested by a machine, program or artificially created consciousness."

ChatGPT, on the other hand, has provided an excellent summary of the definition of AI, which defines the essence of AI in a comprehensive and clear way: 'Artificial intelligence is the design and development of computer systems and applications that can simulate human-like intelligent behaviour and reasoning. AI aims to enable machines and software to learn, understand, interpret, make decisions, solve problems and adapt to changing environments."

BingAI basically copied existing definitions, so we also asked ChatGPT "what were your sources for the wording?" His answer is a remarkable illustration of the essence of AI: "The previous answer was based on my prior training and the knowledge built by the GPT-3 model, drawing on my extensive knowledge of the subject. The information and concepts I used in the answer are the result of knowledge I have acquired from the fields of machine learning, artificial intelligence and computer science." The answer provides an extremely good perspective on the essence of AI and, with it, on the understanding of its concept, which we believe lies in the fact that an IT system solves tasks intelligently based on a database and, most importantly, that it is able to learn and thus change continuously, thus constantly increasing its efficiency.

2.2. Types of artificial intelligence

Artificial intelligence has been gaining ground in recent times, trying to adapt to market trends that go hand in hand with continuous development, so determining how many AI technologies are currently available is extremely difficult. This is illustrated by the statistic that the proportion of companies working in AI has increased 14-fold in the last two decades (Web_3).

AI technology is very diverse, with several different types of AI specialised for a given task.

In the following, we would like to describe the types of AI and how it works that can be used in the field of occupational safety and health. In order to understand the types of AI and the technology, it is important to group them appropriately. According to the currently accepted grouping form, three main types are distinguished, which are:

- narrow general intelligence - narrow artificial intelligence,
- artificial general intelligence,
- artificial super intelligence (Meuwisse, 2023).

Narrow artificial intelligence focuses on solving a specific task. At the current level of development, it is the only AI that can be used in practice. General AI is about making the properties of the AI as similar as possible to those of a human. Currently, the aim of the scientific experts competent in this field is to reach this level as soon as possible. Artificial super-intelligence means a level of intelligence more advanced than that of humans.

To understand the types and techniques of AI, it is important to be able to structure them properly. In Figure 1, we have highlighted in green the types that are currently in practice and can be used in the field of OSH. The main component of narrow AI is machine learning (ML). Deep learning (DL) is a subfield of machine learning, with neural networks as its backbone. Neural networks can also be understood as a stand-alone AI system, but it is important to note that deep learning is also based on neural networks, but the layers and nodes are different, so it should also be understood as a separate AI technology (Web_4).

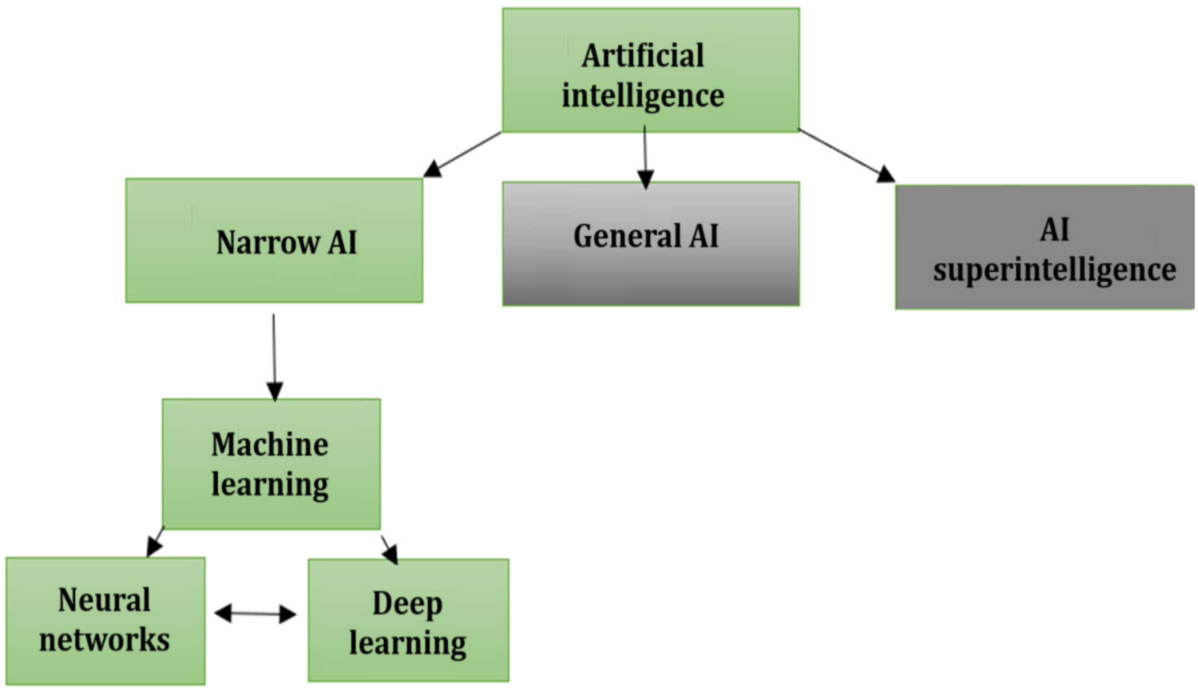

Figure 1
The structural design of artificial intelligence

3. THE USE OF AI IN OCCUPATIONAL SAFETY AND HEALTH

As discussed in the previous chapters, the development of AI is gaining momentum and the percentage of companies using AI technologies is increasing. Businesses are trying to exploit the potential of new technology and use AI to optimise their tasks. Sooner or later, AI systems will also find their way into the world of occupational safety and health, an area where they have huge potential. This will bring a revolutionary change in the world of occupational safety and health, as it will allow more tasks that were previously carried out by occupational safety and health professionals to be partially automated. It is important to emphasise the importance of the word 'partially', as we believe that with the current level of AI development and the current legislative regime in place, this can only happen in a cooperative collaboration between OSH professionals and AI. Artificial intelligences can mainly assist OSH professionals in the fast and accurate analysis of data, who have the knowledge that AI cannot yet replace. Such a level of collaboration could increase the effectiveness of OSH at a high level by significantly speeding up processes, thus providing employers with more time and resources to address OSH tasks and strategies in more depth, which could further improve the OSH culture in a company. As mentioned in the previous chapters, AI models have a long history in robotics and automation, and AI-based systems have made significant advances, particularly in the areas of ergonomics and worker control.

In 2021, the European Agency for Safety and Health at Work has published a policy briefing on the impact of artificial intelligence on safety and health at work. The briefing details that AI-based OSH models offer significant opportunities but also pose serious challenges. The paper highlights the role of AI-based chatbots in informing workers and positively assesses the potential of this technology, but does not provide concrete examples of its implementation. Reference is made to AI models based on workplace and worker monitoring, where the risks of its use for workers, especially from a psychosocial perspective, are highlighted (EU-OSHA, 2021).

The Agency has produced a report on Artificial Intelligence in Workforce Management 2022. The report is about employee management systems based on artificial intelligence. It includes any system that collects data about the workplace and workers, evaluates it with an AI model and then shares information with decision makers. The report refers to them collectively as AIWM systems. These systems focus mainly on employee management. Their main objectives include monitoring workers' work processes, monitoring the length of rest periods in order to increase productivity. An example is given of Barclays PLC, who have introduced an AI model for office workers that monitors the time spent at the workstation and the length of breaks, informing them and their supervisor if they exceed the break length. Specialised AI models for monitoring work space and workers reveal potential risks. As with policy briefing, it sees serious psychosocial risks in its use. This is mainly due to excessive control and constant monitoring, which can have a negative impact on workers' mental health. It points to the possibility that excessive worker control can lead to the 'mechanisation' of people's characteristics, with an artificial intelligence constantly monitoring them and giving instructions on how to perform tasks properly, which can also lead to mental illness and a significant reduction in workers' creativity and problem-solving skills. However, the paper also highlights the positive effects of these types of AI on occupational safety and health. By monitoring the workspace and workers, AI models can monitor workers' postures during work processes and provide signals in case of inappropriate postures, which can reduce ergonomic risks. It can monitor the wearing of personal protective equipment required for workers in a work area. In addition, they can determine a person's mental state at a given moment by facial features and facial expressions and give an immediate signal to a supervisor in the event of a psychological risk. The report refers to its potential use in training, but does not mention specific OSH training, only that it can assist in planning and implementation. It gives a concrete example of AI-based mental health chatbots. This refers to an AI-based application that allows workers to share their thoughts and feelings about any mental health problem or stress situation via a chatbot. The document provides guidance on the preventive measures that employers wishing to implement AIWM systems should take. It stresses that in all cases a risk assessment should be carried out and workers consulted before implementation. They also stress the importance of pre-deployment training to ensure that workers are aware of how the system works (EU-OSHA, 2022).

Taking the following preventive measures further, we recommend the following measures for any AI-based employee management or occupational health and safety system:

– AI systems based on the monitoring of employees should, as required by the GDPR, only take place with the prior written consent of the employee;
– The employer should have a data protection policy and a privacy policy to guarantee the security of employee data;
– Strict internal rules on who can see data from employee audits;
– Establish an AI representative system similar to the OSH representative system. The AI representative would be elected by the employees on the basis of the provision of Act I of 2021 on the Labour Code on works council members. His main task would be to ensure independent supervision and control of the AI schemes;
– In order to ensure full compliance with the following, we would make AI systems related to the monitoring of workspaces and workers subject to notification to the Ministry of Technology and Industry.

3.1. The potential of AI in risk assessment

It can be said that the concept of AI-based risk assessment is not unknown in the world of large corporations, but it is mainly used in connection with financial, data security and IT security risk assessments. These areas are generally easy to apply AI technologies to, as the data source is already available in digital form, making it easier to process. According to our research, there is currently no AI-based OSH-related risk assessment system. The main reason for this is that to develop one, an extremely large database has to be created, which is a complex, time-consuming and costly task. As both quantitative and qualitative risk assessment is required, this requires the incorporation of more and more complex algorithms. Further complicating matters is the multiplicity of risk assessment methods, since in practice the risk assessment model will be the pattern in the AI module. The simplest approach would be for the system to consider an explicit risk assessment method as a pattern and perform the task based on it. This could be generated using machine learning with the right data source and algorithms. In the case where there is a choice of methods in the AI module, the deep learning principle should be applied.

Teaching AI several possible methods results in a much more complex system, which can be implemented using deep learning. The risk assessment method is therefore the pattern that forms part of the database.

In the following, we will draw on our own ideas and the previous chapters to present a simplified conceptual design of a risk assessment AI system. The system would work on the principle of machine learning, thus applying one type of risk assessment method.

As shown in Figure 2., the building block of the system is the database, which is divided into two parts. One part contains the concrete data, which are the workflows and their associated risk values. Another part would be the pattern which is the risk assessment method. We would practically call the creation of the database an OSH professional activity, thus it should be created based on data provided by an OSH professional.

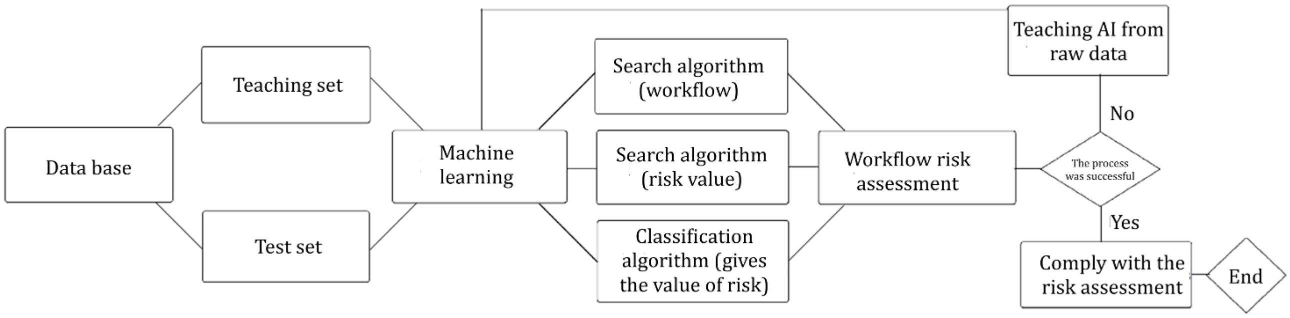

Figure 2
Simplified schematic of an AI-based risk assessment system

Of course, it is possible to imagine a more complex system, but we believe that this would require a neural network and Deep Learning technology.

The outlined system could also be suitable for chemical risk assessments, but the database would have to be supplemented with the contents of the safety data sheets and the pattern would have to be changed according to the provisions of Act XXV of 2000 on Chemical Safety. We intend to present the concept of psychosocial risk assessment in a different way.

In the following, we would like to illustrate the advantages and disadvantages of an AI-based OSH risk assessment system. The advantages would include the following:

- The process is partly automated, which reduces the risk assessment time;
- Capable of processing huge amounts of data;
- Complete objectivity, as it works solely on the basis of data;
- Expandable, changeable database;
- Continuous upgradability.

As already mentioned above, it is important to stress that the main advantage of an AI-based risk assessment system is the time savings due to the partially automated processes. The system is based on a large database that can be continuously expanded and changed to provide more accurate results. All AI systems can be upgraded, and they are constantly evolving, which makes it easy to adapt to changing circumstances. AI systems perform risk assessment based on specified criteria, eliminating the possibility of human error or emotional influence.

The disadvantages of using it are:

- The development alone is costly;
- It is also very expensive to maintain, operate, maintain and improve;
- The creation of the database and the final verification process requires the involvement of an OHS specialist;
- Its possible use requires continuous training for professionals;
- Errors and inaccuracy;
- Limited operational area with the current technical;
- Data protection concerns;
- The legal background varies from country to country.

At the moment, the biggest disadvantage is the costs involved.

3.2. Possibility of its application in the field of OSH training

OSH training is also one of the most important areas in creating and maintaining healthy, safe and non-hazardous workplaces. During training, workers learn about risks and hazards based on risk assessment. The measures they can take to avoid them and the ways and means they can use to avoid hazards in the workplace. Furthermore, the procedures and rules of conduct in the event of a hazardous situation. Employees should be made aware of the applicable legislation and internal regulatory documents. The aim of OSH training is to provide workers with all the information they need to be able to work safely in a given company.

The OSH Act distinguishes between theoretical and practical OSH training. In our opinion, and based on the information available in the literature, the most appropriate training for theoretical training is the use of chatbots. For practical training, there is a huge potential for AI-based virtual reality. Both systems exist and are already being used in many other fields, but the aforementioned systems have not yet been developed specifically for OSH.

In our opinion, the most appropriate solution for OHS training is the use of an NLP Natural Language Processing (NLP) based AI chatbot. The reason for this was that an NLP-based system can perform the task, but is much simpler and therefore more cost-effective than a system that also uses natural language processing.

The NLP-based AI chatbot is based on a database, as it contains the information on which the chatbot builds, i.e. on which it provides answers and information to the user.

A further challenge is the written record of education. In the current online OHS training systems, which are used by many companies, the problem is usually solved by giving workers their own user interface, where they can log in with a unique ID and verify the training by the time spent on the interface or by digital signature. This is feasible for an AI system, but if we are talking about AI, it is worth exploiting its potential and thinking in terms of larger volumes

There is the possibility of a written test to verify the understanding of the training, but we believe that it would be more interesting, more engaging and more effective if the AI asked questions orally, the employee would answer orally and finally the AI would evaluate and record the answers in writing. At the end of the training, the following would be recorded in the employee's user account in a personalised way:

- The subject matter and teaching material of the training;
- The result of the written test or the oral questionnaire;
- A timestamp of when the training took place;
- The date of the next scheduled training.

We believe that supervision by an OSH professional is important for AI-based OSH training, and AI reporting can be a solution.

The benefits of the AI-based OSH education system outlined above are shown below:

- The very nature of AI technology is such that it captures the interest of employees, so they are more attentive to education;
- Employees can take the training flexibly, taking into account their own schedule;
- In the case of facial recognition, maximum verification of identity and continuous monitoring of the employee's attention;
- The possibility to effectively improve the educational material through the AI reports;
- Changeable, expandable database.
- The disadvantages would include the following:
- Costs to be incurred. AI systems can be costly to operate and maintain. And facial recognition is a significant additional cost;
- Data protection. The AI training system includes personal data of employees and monitors their performance due to the end of training test, thus profiling under GDPR. Employers will need to align their internal data protection policies with the AI OHS education system and store the data in a secure manner, which also comes at a cost;

- Some workers may lack human interaction. For example, they may not ask the AI the questions they would ask the safety professional. This can reduce the effectiveness of training;
- Technical problems encountered.

At the moment, we see the greatest potential in the field of occupational safety and health in artificial intelligence-based training systems. Artificial intelligence can be a real breakthrough in this field, as it can provide a modern, engaging and fully interactive learning experience and can adapt flexibly to the needs of workers. In addition, AI-generated reports can be of great help to OSH professionals by offering the possibility to make training more interesting and effective.

The practical part of OSH training can vary from company to company, job to job and work process to work process. The general aim is to familiarise workers with the specific health and safety rules of the workplace. In a practical OSH training course, several training elements are included which, for example, would be almost impossible or very difficult to implement in a working plant. Consider, for example, the introduction to safety equipment. Depending on the technology, it is possible that the activation of an emergency stop could bring an entire factory to a standstill, causing serious damage.

Virtual reality can provide a solution. Because in this case, we would not be demonstrating the operation of a particular emergency stop in reality, but in the same environment, but that environment is created in a virtual space, so that by operating the emergency stop we could watch the safety operations it initiates without causing any production downtime.

CPR training in VR is already widespread abroad, but there is already a company offering this option in our country. However, this VR technology is focused on one task only, but if we integrate an AI module into the system, we can achieve a wide perspective of possibilities and thus make education even more effective by merging VR and AI. With AI, the system would be able to monitor and analyse the performance of workers during virtual resuscitation exercises. Based on the analysis of the data, the AI would be able to identify the strengths and weaknesses of each worker and make recommendations for improvement or further practice.

The AI module in virtual reality also allows you to learn from common mistakes by directly creating situations in the virtual space where the most common mistakes are made by the working salons. This can help workers avoid mistakes that pose a risk or potential danger when performing first aid or in the course of their work.

In our view, the meeting of AI and VR could be a huge breakthrough in the world of occupational safety and health in the possibility of training through the simulated event sequences listed above, as it allows workers to watch or perform practical events and event sequences without risk and to use the experience gained in real life. It should be added, however, that this is currently considered to be the "most inaccessible" technology. The reason is that, in addition to the significant development costs, it also represents an investment in infrastructure, as it requires not only software and AI, but also hardware and VR devices and a dedicated space.

3.3. The potential of AI to inform employees

We imagine informing the workers in a similar way to the theoretical training model presented in the previous chapter, so it would also be based on a chatbot, but in this case the initiative would have to be taken by the worker. This would be done by means of tablets placed in the work area, the operation of which would be restricted to the chatbot. We consider it important to have a very simple user interface, the simplest implementation of which is that the tablet would be equipped with a sensor that detects the presence of the worker and can then ask the question. In practice, if the worker has any question of an OHS nature, he or she can go to the tablet and ask the question verbally, and the AI will generate an answer for the worker, so that he or she can get the information he or she needs very quickly.

The benefits of the system in terms of informing employees are set out below:

- Workers will receive immediate answers to any questions they may have about health and safety;
- When "merged" with the previously described OSH education system, it results in a highly complex OSH education system;
- It is simpler technology than education, and therefore more cost-effective;
- Its database can be expanded and improved on the basis of the reports;
- It does not process personal data.

The disadvantages include the costs involved, as with education-related AI, and the biggest disadvantage is the potential for error, which if not corrected in a timely manner by the OSH professional can pose a serious risk.

The potential of AI in informing employees is greatly enhanced in this case, since for companies that may in the future provide employees with the educational content, employees can ask AI questions based on the previous method. We would add to this idea that, in our personal opinion, companies that only pass on the educational content are unlikely to use AI-based systems for worker protection. We believe that those companies where safety and safety culture is important will, regardless of any changes in legislation, implement safety training either face-to-face, online or via AI.

3.4. Monitoring the working environment with AI

Through a policy brief issued by the European Agency for Safety and Health at Work, AI-based workspace and worker monitoring systems, known collectively as AIWM systems, have been described. The main purpose of these systems is to monitor and control the work processes of workers, for example to check the availability of rest periods or the wearing of personal protective equipment. We would like to approach this issue from a different angle, because, in agreement with the policy brief, we also believe that such continuous monitoring can pose serious psychosocial risks to workers. We see the potential of AI in this case in the further development of mental health chatbots and in the monitoring of the specific workplace, by which we mean the physical parameters of the workplace, such as lighting, air conditions, including air pollution, temperature and humidity, noise levels and the suitability of the workplace.

The policy brief mentions that these systems are able to assess and monitor the psychological state of workers on the basis of facial features and facial expressions. It also introduces mental health chatbots, with which workers can share their mental health concerns and problems. We do not consider the first case to be feasible at present, because we believe that although AI can determine mental state from facial features and facial expressions, it does not yet have the sophistication to determine the cause of a negative or positive mental state over such a large area and not in a specific but continuous action. In any case, we envision its application in an online interface where workers can log in anonymously.

As this is a very complex process consisting of several structures, with current technology this can be done using deep learning. We envision that the ML model requires three input layers, i.e. three separate data sources. The first input layer would be the conversations of the mental health chatbot, the second would be the questionnaires to be filled in annually and the third would be the OMMF guide. The hidden layer would contain the psychological context. The output layer would carry out the risk assessment.

The use of AI can significantly increase the level of safety in the specific workplace control, as it can be used to perform continuous monitoring by specifying the conditions and parameters.

This can be achieved with the aid of sensors or directly through an MI module integrated in the equipment monitoring system.

Systems are already in place to control the location of work using artificial intelligence. In our view, the biggest step forward in this has been made by Hinduja Global Solutions, who have developed an AI-based system that can monitor workplaces and analyse data based on that.

The benefits of using AI to monitor workspaces are shown below:

– It has a risk-reducing effect thanks to continuous monitoring, evaluation and forecasting;
– Cost savings can also be achieved through the control and optimisation of building automation;
– It can be used for long-term analysis, which can help improve processes.
– The disadvantages are highlighted below:
– It is largely connected to existing systems (e.g. gas detectors, air conditioning and air handlers) so there is a greater potential for failure;
– Strict data protection provisions must be put in place, as trade secrets are handled by the AI system.

3.5. Worker inspections by the AI from an OSH perspective

With the solutions offered by artificial intelligence, it will be possible to monitor workers for wearing personal protective equipment. These are existing and operational systems and are the most widely used in the field of occupational safety and health in terms of AI. The architecture of these systems is very similar to that of workplace monitoring, since here too we are talking about the interaction of camera systems and AI. If the worker is not wearing the required personal protective equipment, the system immediately sends an alarm. Based on our research, three development companies have already developed AI-based personal protective equipment monitoring systems that work on the principle outlined above. The market leader among these companies is Hikvison (Web_5), but it is also important to mention the merits of EasyFlow (Web_6) and Pervasive Technologies (Web_7).

Figure 3
EasyFlow personal protective equipment control system (Web_6)

It would be advisable to integrate the system into the occupational health software used by the company, so that the occupational health specialist can analyse the data at specified intervals and consult the worker at the time of the medical fitness assessment. In this way, the system would be an innovation for occupational health as well as for occupational safety.

4. USE OF AI IN OCCUPATIONAL HEALTH AND HEALTH AT WORK

Fitness for work shall be decided on the basis of a medical examination provided for in a special law."

These tasks place a heavy administrative burden on companies employing hundreds or even thousands of workers, and keeping track of the timeliness of medical fitness tests for employees is a major challenge. Although AI is already used quite extensively in the health sector, mainly in the diagnostic field, its use in occupational health has not yet been widespread. In our view, AI could help to fully automate the follow-up of medical fitness tests, reducing the administrative burden on businesses.

Based on the database, the AI is able to analyse the data and use a timing algorithm to notify the employee or his/her immediate supervisor of the due date of the periodic medical fitness test at a specified time interval before the expiry of the medical fitness. In the field of occupational health and development, the principle of a mental health chatbot would be applied.

5. SUMMARY

Artificial intelligence is not a new technology, with a history going back nearly 70 years. However, it has evolved rapidly over the last decade and as a result has become part of our everyday lives. Companies are trying to exploit its potential in order to increase their efficiency. As a result, the artificial intelligence market has become highly competitive, leading to a rapid development of the technology.

In our research, we first reviewed the definitions of AI in the literature to provide a theoretical background and principles of AI. We then explained the principles of AI and described in detail the AI technologies that can be applied in the field of occupational safety and health. We identified these as machine learning, neural networks and deep learning. Based on literature sources, we described the subsystems of AI modules that were mentioned in the presentation of the presented AI-based OSH systems.

In the main part of our work, we have described in detail the areas of occupational safety and health where AI-based systems can be applied. We have presented systems that are already in operation and highlighted those areas that are still untapped, where the application of AI can offer innovative solutions. Drawing on the literature and the previous chapters, we have described AI solutions in the field of OSH that have not yet been implemented or can be further developed.

The final conclusion is that artificial intelligence could become a common part of occupational safety in the near future. The cooperative collaboration between the OSH professional and AI could be the basis for the birth of modern OSH.

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HUMAN SAFETY IMPACTS OF THE USE OF CHLORAL-BASED WATER TREATMENT OXIDATORS

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Abstract: The aim of our research is to explore the occupational health and safety aspects of the technological challenges related to the new drinking water quality requirements for chlorine-based oxidants in the new drinking water quality regulation 5/2023 (I. 12.). Based on the literature, previous cases and our own experience, we identified the risks of these substances and technologies, which were subjectively assessed depending on the amount of data available. The results of the risk analysis confirmed the previously hypothesised problem: sodium hypochlorite solution technology is superior in safety terms compared to chlorine gas and chlorine dioxide technologies. In order to respect the principle of "substitution of hazardous by non-hazardous or less hazardous", it is recommended to use the sodium hypochlorite-based technology, avoiding an unjustified change of technology. However, regulatory compliance may require the introduction of chlorine gas dosing: the research will not only demonstrate good practices but also support the development of safe and healthy working conditions by presenting state-of-the-art technical solutions.

Keywords: *water treatment, EHS, chlorine oxidants, human effects*

1. INTRODUCTION

Chlorination has become one of the most commonly used water treatment processes in Hungary, not only for disinfection purposes but also because of the oxidation of inorganic components. However, the disadvantage is the formation of chlorination by-products which are harmful to the health of consumers. Technological progress is making the detection and monitoring of these substances more effective, and the requirements for drinking water are therefore becoming more stringent. The EU Directive 2020/2184 on drinking water intended for human consumption sets more and stricter parametric values for drinking water than the previous regulation, so the parametric value of chlorate, which was not regulated before, has been included in the Hungarian legislation (Government Decree 5/2023 (I. 12.).

Chlorate is a harmful decomposition product of chlorine-based oxidants, mainly present in high concentrations during the thermal decomposition of NaOCl. In water treatment, it is mainly present in drinking water in above-range concentrations during breakpoint chlorination with sodium hypochlorite (Stefán et. al, 2019). The problem is widespread, with a National Centre for Public Health study of 295 waterworks finding that more than half of the samples contained chlorate in above-range concentrations (Stefán et al.), In many cases, compliance with the changing regulations may mean switching from hypo-solvent breakpoint chlorination to chlorine gas technology, which can pose a number of risks to workers and bystanders. Thus, our work has summarised the effects of chlorination on workers, as the latter aspect is less emphasised in professional fora.

2. THE USE OF CHLORINE-BASED OXIDANTS IN WATER TREATMENT

Chlorine (Cl) is one of the chemical elements that belong to the halogen family. Halogens do not occur naturally in the elemental state due to their reactive nature, but are common in the form of ions. Chlorine is most commonly found as chlorides, such as sodium chloride (NaCl) or potassium chloride (KCl). Chlorine is the twentieth most abundant element in the earth's crust and more than half of the average 3.4% salt content of seawater (1.9% by weight) is due to chloride ions. Chlorine is produced by the electrolytic oxidation of chloride ions. Since chloride ions are available in large quantities and chlorine is produced in large quantities for industry - globally about 100 million tonnes per year, a growing trend (Web_1), which is also cost-determining - chlorine-based water treatment has become common in developed countries, including our own (Greenwood and Earnshaw, 1997).

The purpose of their application is to comply with the parametric values and limit values set out in Government Decree 5/2023 (I. 12.), and to ensure the fundamental human right - access to drinking water - as defined in the Fundamental Law. According to the Decree, water is considered drinking water if it does not contain microorganisms, parasites, chemical, physical or radiological substances in quantities or concentrations that could pose a potential risk to human health. If the limit values are exceeded, the water is not considered to be drinking water and corrective action must be taken without discretion. The Regulation sets limit values for microbiological water quality characteristics (E. coli, Enterococcus) and chemical water quality characteristics (e.g. arsenic). Where parametric values are exceeded, the presence of these indicators in drinking water must be assessed and considered to determine whether they pose a risk to human health. Such indicator water quality characteristics are ammonium, iron, manganese, colony count, coliform bacteria, Pseudomonas aeruginosa, and microscopic biological quality characteristics. Although drinking water quality requirements are met when parametric values are exceeded, drinking water is considered to be of tolerable quality. Where a risk to health cannot be clearly excluded, corrective measures must be taken to improve the water quality to a level that meets the requirements for the protection of human health.

Chlorine is the main oxidising agent that can react with a wide range of pollutants. Due to the high electron affinity of chlorine, reducing substances easily lose their electrons, the substance that loses electrons is oxidised, i.e. it requires an oxidising agent (Öllős, 1998). This chemical process can be used to take corrective measures to bring raw water to a state suitable for human consumption.

3. PHYSIOLOGICAL EFFECTS OF CHLORINE-BASED OXIDANTS USED IN WATER TREATMENT

In Hungary, an occupational activity with a hazardous substance or hazardous mixture may only be started in possession of a safety data sheet for the given hazardous substance or hazardous mixture pursuant to Section 28 (3) of Act XXV of 2000 on Chemical Safety, and this document is also indispensable for the risk analysis pursuant to Section 5 of ITM Decree 5/2020 (6.II.).

Safety Data Sheet (SDS) is a document in English, compiled in accordance with Article 31 of REACH, which contains, among other things, the data necessary to identify the substance or mixture, provide information on its physical and chemical properties, identify its effects on health and the environment, and give instructions on fire protection, transport, storage, disposal measures to manage the hazards.

In order to enable workers to carry out activities involving dangerous substances in a safe manner and to provide them with information on the hazards involved, personal protection and first aid, the employer must provide workers with the content of the safety data sheets in a language they understand.

The physiological effects and mechanisms of action of marketed oxidants used in water treatment or substances necessary for their manufacture are described based on information available in the T3DB (Toxin-Toxin-Target Database) database (Wishart et. al, 2015), designed to collect toxic exposure data, or the HSDB (Hazardous Substances Data Bank) database (Fonger, 1995) maintained by the U.S. National Library of Medicine, and classified by hazard as specified in the CLP Regulation.

3.1. Sodium hypochlorite

Sodium hypochlorite (CAS No 7681-52-9) is a strong oxidising agent. According to T3DB data, oxidation reactions are corrosive, causing skin and eye damage, especially in concentrated form also used in water treatment. Hypochlorous acid (HOCl) is known to cause post-translational modifications of amino acids in proteins, most notably oxidation of cysteine and methionine. These oxidation reactions can lead to protein aggregation and denaturation, which can result in cell death and tissue damage.

A small amount of chlorine gas can be formed from the sodium hypochlorite solution, which when inhaled can cause coughing, sub-coughing, pain under the sternum, difficulty breathing, shortness of breath and wheezing. Symptoms may be delayed. Ingestion may cause pulmonary oedema, vomiting or coma. The nausea and vomiting are reflex in origin, and the headache and loss of consciousness are probably due to hypoxia caused by pulmonary oedema. Contact with the skin may cause redness, pain and reddening of the exposed surface, causing hypersensitivity or other allergic reactions. Eye contact may cause watering of the eyes, failure to rinse after exposure may result in permanent damage. Animal studies have shown no carcinogenicity by either oral or dermal routes.

3.2. Chlorine gas

Chlorine (CAS No 7782-50-5) is a strong oxidising agent that hydrolyses in water. According to the T3DB, chlorine in hydrolysed form can penetrate the cell and form N-chlorine derivatives that damage cell integrity. Chlorine also reacts with water in the epithelium of the upper airways to form hypochlorous acid. It is a more powerful oxidant than chlorine gas, as reflected in its higher redox potential.

The main targets of exposure to chlorine gas are the respiratory tract: coughing and vomiting can occur at concentrations of 30 ppm and lung damage at 60 ppm. Around 1000 ppm can be fatal after a few breaths. Symptoms are typically delayed: mild nasal and eye irritation, headache and throat irritation, coughing, respiratory distress may follow, followed by pulmonary oedema and hypoxia, and may further increase capillary permeability. Further complications can lead to pneumonia and even death.

Contact with the skin can lead to redness, pain and reddening of the exposed surface. Eye contact may cause watering of the eyes. Ingestion of chlorinated water may lead to erosion of the mucous membranes of the oesophagus and stomach, perforation of the gastro-oesophageal junction and extensive necrosis of adjacent soft tissues.

3.3. Chlorine dioxide

Possible symptoms of exposure to chlorine dioxide (CAS No 10049-04-4) gas include eye, nose and throat irritation, cough, wheezing, bronchitis and pulmonary oedema, according to the

HSDB. Workers exposed to low concentrations of airborne gases in industry have been observed to suffer occasional eye irritation, but these effects are minor compared to respiratory irritation. Bronchoscopy and biopsy revealed mild chronic bronchitis in 7 out of 12 workers. In workers acutely exposed to chlorine dioxide, it may cause reactive airway dysfunction syndrome, a form of occupational asthma. Experimental evidence suggests that it does not bioaccumulate, is not persistent, and is not a carcinogen.

A further risk is the risk of explosion, which is why it is produced in-situ. The safety data sheets required for this activity, provided by the supplier, refer to chlorine dioxide precursors. Since chlorine dioxide used in water treatment is not placed on the market, it is not covered by the CLP Regulation on classification, labelling and packaging. Nevertheless, a description of the hazards listed in the Regulation is, in our opinion, necessary for comparability with other oxidising agents and to illustrate the difference between chlorine dioxide as a gas and as a solution.

During water treatment, chlorine dioxide is produced as a less hazardous solution, but it can also occur in gaseous form as a result of malfunction or omission. In addition to the explosion hazard, the acute toxicity classification of ClO_2 gas in category 2 (minimum) is emphasised, a category higher than chlorine gas. Estimated acute toxicity: 100 ppmV < ATE ≤ 500 ppmV.

It also has a higher classification than chlorine gas for skin and eye effects, its classification as category 1B already indicates a risk of irreversible damage, with animal studies showing that symptoms occur after 3 minutes to 1 hour of exposure and up to 14 days of observation.

In view of the above, although during normal operation a solution is formed which is diluted after its formation, knowledge of the properties of the substance (and its precursors) is essential for safe and health-safe working.

3.3.1. Sodium chlorite

According to the HSDB, studies with sodium chlorite (CAS No 7758-19-2) in a number of species have shown oxidative stress associated with changes in erythrocytes (red blood cells). This observation has been confirmed by a number of in vitro biochemical studies. Some studies have shown that the effect may be related to a reduction in serum glutathione antioxidant levels, thereby reducing the body's ability to protect erythrocytes from the effects of sodium chlorite. Other studies have shown that sodium chlorite can damage the erythrocyte membrane. However, no clinically significant lesions due to sodium chlorite have been shown in human experiments. It is not classified as carcinogenic, persistent or bioaccumulative in human or animal studies. However, it is highly irritating to the skin, eyes and respiratory tract.

Annex VI of the CLP Regulation does not contain a harmonised classification for sodium chlorite, and therefore manufacturers, importers or downstream users are required to classify sodium chlorite before placing it on the market. As no mandatory classification is available, a classification according to the safety data sheet of a mixture also used in water treatment (Vinyl, 2020).

3.3.2. Hydrochloric acid

According to the T3DB database, gaseous hydrogen chloride (CAS No 7647-01-0) forms corrosive hydrochloric acid in contact with water in body tissues. Inhalation of vapours may cause coughing, choking, inflammation of the nose, throat and upper respiratory tract, pulmonary oedema, circulatory system failure and death in severe cases. Hydrogen chloride or its aqueous solution (hydrochloric acid) may cause redness, pain and severe burns on contact with the skin. Both hydrogen chloride gas and hydrochloric acid can cause severe burns and permanent eye damage. Ingestion of hydrochloric acid causes severe and rapid corrosive burns to the mouth, oesophagus and gastrointestinal tract. Symptoms include burning sensation, choking, nausea, vomiting and severe pain. Concentrated hydrochloric acid (fuming hydrochloric acid) forms an acidic mist. Both the mist and the solution are corrosive to human tissues and can cause irreversible damage to the respiratory system, eyes, skin and intestines. When hydrochloric acid is mixed with common oxidising chemicals such as sodium hypochlorite or potassium permanganate, toxic chlorine gas is formed. Chronic exposure to hydrogen chloride can lead to liver damage, bleeding from the nose and gums, ulceration of the nasal and oral mucosa, conjunctivitis, yellowing of the teeth and erosion of tooth enamel, and dermatitis.

4. GOOD PRACTICE FOR CHLORINE-BASED OXIDANT APPLICATION

In order to identify the hazards associated with the use of chlorine-based oxidants and to make oxidants comparable with each other, it is first necessary to define good practice in their use. The demonstration of good practice is the basis for the subsequent identification of hazards. The definition of good practice is grouped according to the activities involved in the use of oxidants, which also provides a basis for hazard identification and risk assessment. These are: transport; storage; application; waste management. Good practice is presented and hazards are identified on the basis of the legislation and standards already referred to, the CLP Regulation and safety data sheets, and the machine manuals and instructions for use.

Application means storage at the point of use, transfer of oxidising agents to the dosing tank, replacement of pressure vessels, inspection, maintenance and troubleshooting of dosing units.

Chlorine gas

No worker may carry out chlorine gas activities alone. When replacing pressure vessels, the health and safety requirements for manual handling must be observed, as the weight of the vessels, regardless of how full they are, can be considerable. The vessels may only be operated with protection against shifting. The connection of the chlorinator to the vessel must not be disconnected until the chlorine valve is fully closed. When connecting a new vessel, a screwed-on lock nut shall be used to ensure that the valve can be opened. The valves of vessels shall be opened with extreme caution, avoiding excessive torque and rapid movements. If the valve is frozen, it should be heated with water or air at a maximum temperature of 40°C. The connecting surface of the valve shall be cleaned and a new gasket shall be fitted in all cases. The gas tightness must be checked by means of a cotton wool dipped in ammoniacal spirit; in the event of leakage, smoke will be formed. When changing the pressure vessel, the worker carrying out the change must wear protective clothing, respiratory protection and acid-resistant protective gloves and footwear until the gas tightness has been checked in the operating state.

In the event of a pressure vessel valve leakage, the vessel must be closed and the fault marked, but the filling station will be responsible for troubleshooting. If chlorine gas is leaking into the air space due to a defect in the pressure vessel or its fittings, a large quantity of slaked lime (which should be available on site) should be placed around the defect location to bind the chlorine. If the leakage occurs at the connections between the vessel and the vacuum regulator, the worker shall locate and repair the fault. If the leak is located at the safety control valve of the vacuum regulator, the leak is in the drain line - it is rectified by replacing the stirrup. The gas contained in the chlorine gas dosing device shall be vented to free space for periodic degassing (maintenance, repair, cylinder replacement, etc.). The pipework (drainage pipe) for the degassing facility shall be installed vertically, higher than the highest building in the immediate vicinity, and shall extend at least 50 cm above the roof ridge. In other cases, provision must be made for the absorption of chlorine gas.

In addition to troubleshooting, the chlorinator operator must also perform maintenance tasks (e.g., cleaning the stirrup filter, cleaning the rotameter, cleaning the control valve, cleaning the ejector check valve and ejector nozzle) where the worker may come into contact with chlorine gas. In addition to technological problems, lack of maintenance can also cause safety problems, e.g. safety valve not closing perfectly due to contamination, which can lead to gas leakage without vacuum: gas is then released through the exhaust pipe.

The dosage is operated by a vacuum, which is created by an ejector. The ejector requires running water to operate, it does not directly require a power source: there are no electrical hazards resulting from the maintenance of the dispenser. However, the presence of these hazards cannot be excluded due to the electric motor-driven pump providing the flow of process water, other equipment in the room (e.g. ventilation) and the potentially corrosive environment: adequate protection (at least IP54) must be provided.

Sodium hypochlorite

At the point of dispensing the sodium hypochlorite solution, the storage requirements must be met, except that it must be decanted from the original packaging into the dispensing container if the dispensing pump cannot be installed directly on the original packaging. It is recommended to use a transfer device (e.g. transfer pump) instead of direct pouring. The device should be decontaminated after use. The devices should not be used or should only be used for spraying other chemicals after proper cleaning to prevent accidental reactions. When transferring to an empty dosing tank, it should be noted that the dosing pump will start dosing immediately if it is not de-energised or set to 0% volume dosing: the operating pressure can be up to 10 bar, causing splashing of the solution in case of a broken system. Care must be taken to ensure the provision and use of personal protective equipment: prevent the solution from entering the eyes, skin or inhaling its vapour. In the event of exposure, ensure that the solution can be removed from the skin or eyes at the workplace, e.g. by using a safety shower or eye wash station (Vinyl, 2019). Keep all unused containers closed and place a damage prevention tray under the dispensing container and under the containers. Ventilation should be provided due to the risk of chlorine gas release.

The dosing pump is powered by an electric motor, and the protection (IP65) is guaranteed only if the covers, protection caps and plugs specified in the instruction manual are in place. It must be disconnected from the mains during maintenance. To ensure long life and to maintain dosing accuracy, the condition of wearing parts (diaphragm, valves) should be checked regularly and worn parts replaced as necessary.

During maintenance, the drain hole should be checked daily for dirt and leaks. Also check for leaks in the valves and dispensing head. Every two years or after a maximum of 8 000 operating hours, the diaphragm and valves must be replaced. If the diaphragm is damaged, the dispensed liquid escapes through the drain hole and the safety diaphragm protects the pump housing from the ingress of the dispensed liquid. When dispensing crystallising liquids (such as sodium hypochlorite solution), the drain hole may become blocked by crystals, which may cause pressure to build up between the diaphragm and the safety diaphragm. The pressure can cause the solution to enter the pump housing through the safety diaphragm, which can damage the pump and IP protection can no longer be guaranteed.

Waste generated during use must be treated as hazardous waste. For example, materials contaminated by cleaning, damaged packaging, solution released into the environment through a vent valve or drain hole. The vent valve pipe should be routed into a tank and the spillage collected, but no hose should be attached to the drain hole (as this would prevent detection of leakage).

Chlorine dioxide

The production and administration of chlorine dioxide involves both the risks associated with the presence of hydrochloric acid solution and sodium chlorite solution and the risks associated with the presence of the chlorine dioxide produced. In addition, the dosing room must be prepared for a possible leakage of chlorine dioxide: if there is no other way to ensure the protection of workers, a gas detector must be installed which will automatically shut down the equipment and send a remote alarm if the hazard persists. In the event that automatic shutdown is not possible, or in the event of a malfunction undetected by the gas detector, which would make access to the equipment dangerous, the operator must be able to shut down the equipment from a safe distance. To this end, the emergency stop switch must be located near the door of the plant room, outside the room and easily accessible.

To ensure a controlled reaction, the two precursors must never come into contact with each other outside the reactor. Precursors should be prevented from flowing together (use of damage prevention trays) or from interchanging dosing sites (e.g. by labelling or different colour marking). Spillage or splashing of materials should be avoided: it is recommended to use containers with the appropriate capacity for the application, avoiding transfer or transfer to dosing vessels. If spillage is necessary, do not use spillage equipment without cleaning to avoid cross-contamination. Only dilute solutions of hydrochloric acid and sodium chlorite should be used, as the undiluted form is explosive in the reactor.

According to EN 12671:2016, the chlorine dioxide solution prepared on site should be stored at a concentration of less than 3 g/l for less than 30 minutes within a pH range of 2.0-5.5. Suitable materials: dark brown glass or borosilicate glass, PVC, cross-linked HD polyethylene, polyfluorocarbons. Chromium steel and stainless steel are less suitable for contact with chlorine dioxide. Rubber and general plastics must be certified as resistant to chlorine. The operating documentation for the chlorine dioxide plant specifies requirements for the bypass material: only polyvinylidene fluoride (PVDF) or PN16 pressure grade PVC pipes should be used (ProMinent, 2019).

During operation, care must be taken not to exceed the permissible operating pressure. Chlorine dioxide vapour or chlorine dioxide solution may leak from a bypass which becomes unsealed or damaged. To prevent clogging, the bypass shut-off valves must be opened before operation and the flushing valve must be opened before charging the reactor: when closed, the pressure of the chemical feeders may cause the above units to rupture.

At too high an operating pressure, the formation of a vacuum can also have negative effects: uncontrolled suction and chlorine dioxide formation, as well as water and gas phase formation in the bypass. If the bypass is not completely filled with water or there is no service water flow, it can also cause chlorine dioxide to be gasified. If the gas fraction reaches critical concentration, the reactor may explode. A vacuum interrupter must be used against such malfunctions.

An explosion hazard can also occur if the flow meter in the bypass is blocked by contamination, which can cause chlorine dioxide concentrations to exceed the permitted level. To avoid this, the service water must be already purified or filters must be used in the upstream section of the pipeline.

When operating the reactor, care must be taken to ensure that the system is leak-proof, as unsealed, damaged hoses or piping can leak sodium chlorite and hydrochloric acid solution, or in worse cases chlorine dioxide solution or steam. To ensure this, regular maintenance should include checking the condition of hoses and lines, hydraulic connections, and the closed condition of the flush valve. Unintentional opening of the flush valve must be prevented by means of a lockable device.

Before opening the closed system for any maintenance work, it must be flushed with water to remove hazardous substances. Maintenance should include cleaning of the equipment, particularly to ensure the operation of the vacuum interrupter and flow meter. It is also necessary to check the seals of the electrical system to maintain IP65 protection, as chlorine dioxide can corrode circuits and can cause electric shock when it enters a humidity control.

The dosing pumps for the chlorine dioxide plant are governed by the dosing requirements for sodium hypochlorite already described.

Only trained persons may enter the premises. To this end, the room must be equipped with a lockable door with appropriate signs and markings (Decree 2/1998 (I. 16.) MüM). Unauthorised access can also be prevented by password protection of the control panel of the equipment.

5. COMPARISON AND CONCLUSIONS

The risks associated with the use of chlorine-based oxidants have been identified and estimated. In terms of the number of risks identified, as expected, the use of sodium hypochlorite solution poses the least risk (Table 1.). Also, when the estimated values of the identified risks are summed up, the use of sodium hypochlorite is found to be the least risky. This is followed in order by chlorine gas, then by chlorine dioxide production and use, both in terms of number of units and in terms of total values. The high number and overall risk associated with the use of chlorine dioxide is explained by the in-situ production: the risks associated with the technology include not only the chlorine dioxide produced but also the hazards of the hydrochloric acid and sodium chlorite solutions needed for its production.

The breakdown of the aggregate risks by severity also reflects the more favourable use of sodium hypochlorite from an occupational safety point of view: only the electrical hazards associated with the use of the dosing pump and associated equipment represent a high risk. The high-risk hazards of chlorine gas and chlorine dioxide are of similar magnitude in terms of number and overall value, with both being characterised by material hazards and combinations of hazards (typically due to some kind of fault or storage irregularity), but the electrical hazards associated with chlorine dioxide technology are also significant. However, among medium risk hazards, chlorine dioxide use is over-represented, with the combined presence of the three substances, each of which is hazardous. Chlorine dioxide is also the highest risk source in terms of number of items and total value, while sodium hypochlorite is the lowest.

Table 1

Number and aggregated values of risks identified

	Cl_2		**NaOCl**		**ClO_2 (HCl, NaClO)$_2$**	
	nb	**total value**	**nb**	**total value**	**nb**	**total value**
Total risk	35	217	25	141	58	374
of which Low Risk	9	26	10	34	14	50
Medium risk	15	81	13	87	34	224
High risk	11	110	2	20	10	100

Table 2. shows the distribution by type of hazard, showing that material hazards are the most prominent for all three technologies. For chlorine dioxide, the number of hazards arising from the properties of the hazardous materials is the highest (due to the presence of hazardous precursors), but the number of hazards per unit value is similarly higher for chlorine gas than for chlorine dioxide. Ergonomic hazards (fatigue) can be considered the same for all materials, arising from manual handling. However, in the field of mechanical hazards, chlorine gas can be mentioned due to instability resulting from the design of the pressure vessels. The packaging of other chemicals allows for more stable storage and transport (e.g. brick body design, low centre of gravity, lower mass), as their design does not need to withstand internal pressure (e.g. cylindrical body, higher centre of gravity, high mass). Electrical hazards are present for all three materials: although chlorine gas dosing does not directly require electricity, the combination of

ventilation, lighting, temperature assurance required during both storage and use, and the potentially corrosive environment, create risks. In contrast, sodium hypochlorite and chlorine dioxide technologies also require electricity directly and therefore have higher risk values for electrical hazards - although the electrical hazards are less pronounced during storage than for chlorine gas. The high number of hazard combinations highlights the importance of proper design of storage and dosing locations and the importance of maintenance - with the consequences being more pronounced for chlorine gas and chlorine dioxide technologies, where there is a risk of asphyxiation and explosion, in addition to the risk of corrosion, fire, respiratory distress (irritation) due to the material properties of the oxidising agents.

Table 2

Distribution and aggregated values of identified risks by type of hazard

	Cl_2		NaOCl		ClO_2 (HCl, NaClO)$_2$	
	nb	**total value**	**nb**	**total value**	**nb**	**total value**
Material	12	78	17	89	43	268
Ergonomics	1	3	1	3	1	3
Mechanical	5	20	0	0	0	0
Electricity	4	20	2	20	2	20
Danger combination	13	96	5	29	12	83

Based on the distribution of identified risks by activity (Table 3.), for all three substances, waste treatment is considered to be the least and least significant overall work phase. These hazards typically reach a low to medium risk level. The transport work phase also typically presents low to medium risks for sodium hypochlorite and chlorine dioxide precursors. However, the transport of chlorine gas represents a relatively high number of items and high risk sources.

Table 3

Distribution and aggregated values of identified risks by type of hazard

	Cl_2		NaOCl		ClO_2 (HCl, NaClO)$_2$	
	nb	**total value**	**nb**	**total value**	**nb**	**total value**
Transport	12	73	5	23	9	45
Storage	10	61	6	27	13	61
Apply at	9	66	9	66	25	210
Waste management	4	17	5	25	11	58

The use of hazardous substances also involves hazards in storage, and therefore involves higher risk values. In storage, hazardous substances are at rest and not worked with: hazards typically arise from environmental hazards, as well as from faulty packaging and improper storage. Application, on the other hand, requires active human intervention and workers are at increased risk from oxidising agents. These may arise not only from material properties but also from human errors and omissions. In the case of chlorine dioxide, the high proportion of hazards during application is most striking: 43.1% of the total number of hazards and 56.15% of the total value of hazards can occur at this time.

In conclusion, if compliance with Directive 2020/2184 and its promulgating Government Decree 5/2023 (12 I) is achieved by replacing the technology using sodium hypochlorite solution with chlorine gas or chlorine dioxide technology, occupational safety could be adversely affected based on the risks identified. Such a change of technology is not only contrary to the previous trend (in the past decades, chlorine gas dispensers were replaced by sodium hypochlorite dispensers), but also raises compliance with Section 54(1)(f) of the Occupational Health and Safety Act: in order to ensure safe work without endangering health, the employer must also take into account the general requirement of "substituting a dangerous product with a non-dangerous or less dangerous one".

In order to comply with the amended Regulation and the principles of occupational health and safety, it is recommended to prioritise good practice in the dosage of existing sodium hypochlorite: by designing appropriate chemical storage rooms, light and heat degradation can be avoided, and using a lower concentration of solution will slow down degradation (e.g. Using a lower concentration of solution (e.g. 90 g/l instead of 150 g/l, or diluting a more concentrated solution), and eliminating the presence of metal ions will also reduce degradation (e.g. plastic containers, high purity water free of metal ions in dilution). Eliminating degradation will also reduce unwanted chlorate growth. In addition, care should be taken to adjust the dosage correctly, as lower, but appropriate concentrations can also reduce chlorate formation. If correct storage and dosing of sodium hypochlorite is ensured and the drinking water produced complies with the new quality limits, there is no need to switch to riskier technologies.

Since chlorate formation above the limit value is mainly typical for water treatment processes requiring high chlorine dosage, such as sodium hypochlorite breakpoint ammonium removal (Stefán et. al, 2023), in some cases a change of technology may be unavoidable. Fracture-point chlorination cannot be performed with chlorine dioxide, so in such cases a switch to chlorine gas dosing may be an option. In the following, suggestions for improving safety at work are presented for switching to chlorine gas dosing, taking into account the priority of technical solutions over personal protection:

- Designing a chlorine gas storage and dosing site can be difficult due to high costs and the inherent difficulties of locating on sites not designed for this purpose. In many cases, enclosed and protected from environmental impacts, non-human occupied and non-interior spaces are not available. To provide a safe dispensing area, chlorination booths are commercially available, equipped with lighting, heating and ventilation. The fibreglass reinforced plastic enclosure is sun and weather resistant, with a steel floor and support structure to accommodate chlorine cylinders.
- An air monitoring device should be installed to detect chlorine gas entering the airspace of the room and to eliminate the hazard.
- In the event of a chlorine gas spill, a gas scrubber may be used to dechlorinate the air. An example of such a device is the dry gas scrubber from PureAir Filtration, LLC (Figure 1.). The Sentry™ Emergency Gas Scrubber (EGS) is loaded with an alumina adsorbent through which an exhaust fan circulates the contaminated air while the chlorine adsorbs on the surface of the load. The adsorbent itself is non-flammable and, unlike wet scrubbers, does not produce a hazardous solution requiring treatment.
- Although the chlorine gas is routed to the vacuum valve by the shortest possible route, from where it can be safely dispensed, there is a risk of gas leakage at the pressure vessel connection point. A safety shut-off valve and an air gap analyser allow the gas path to

be closed without human intervention. The device consists of three parts: valve, actuator and control unit. The latter receives the signal from the air gap analyser and is equipped with status indicator lights and push buttons for setting the end position.

Figure 1
Sentry™ Emergency Gas Scrubber dry gas scrubber (Web_2)

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RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT FOR WORKERS IN THE WATER UTILITIES SECTOR

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Abstract: The main objective of our work was to recommend a personal protective equipment benefit scheme for workers in specific water utility jobs, namely water engineers, wastewater operators and network maintenance workers. The characteristics of the specific water utility jobs were described, and with this in mind, the risks associated with the jobs were identified and the need for personal protective equipment was determined. The minimum conditions for the required protective equipment were determined, resulting in a recommended list of personal protective equipment for the jobs. Finally, we recommend more innovative solutions that, if implemented, could potentially provide a more effective and higher level of protection for workers involved in water utility services, beyond the minimum requirements for personal protective equipment.

Keywords: *water utilities sector, protective equipment support system, EHS, PPE*

1. INTRODUCTION

The most important regulator for water utility companies in the European Union is Directive 2000/60/EC of the European Parliament and of the Council on water policy, commonly known and used as the Water Framework Directive (WFD), which together with its related legislation and regulations sets out the main objectives to be achieved in relation to the quality of drinking water and the protection of water (MaVíz, 2015).

In Hungary, the fundamentals of the water utility service sector are defined and enforced by the current Act CCIX of 2011 on Water Utility Services and Government Decree 58/2013 (27.II.). Article 3 of Act CCIX of 2011 states that the Hungarian Energy and Utility Regulatory Office (hereinafter: the Office) shall act over water utility solvent suppliers in administrative authority matters. Article 35 of the Act stipulates that water utility services may be provided only in possession of a water utility licence and an operating licence issued by the Office. Article 37 of the Act further provides that the water utility operator is entitled and obliged to carry out its activities exclusively in the area of supply specified in the operating licence issued by the Office.

The water utility service can be divided into two main areas; piped drinking water supply and public sewerage. From the drinking water sector's point of view, the concept of water utility covers a public facility for the supply of drinking water to the municipality(ies), including the production, treatment, storage, transport, distribution and delivery of drinking water to the point of use, while protecting the drinking water resources. From the point of view of the wastewater sector, we can talk about a facility that collects, drains, purifies, treats the sludge generated and disposes of the treated wastewater (Act CCIX of 2011).

2. PRESENTATION OF SECTORAL JOBS

The organisational structure of companies providing water utility services is generally hierarchical. In a hierarchical structure, several levels of management can be identified, with managers at different levels having different levels of responsibility and authority (Dobák and Antal, 2016). The possible hierarchical structure of management levels in a water utility service provider is shown in Figure 1.

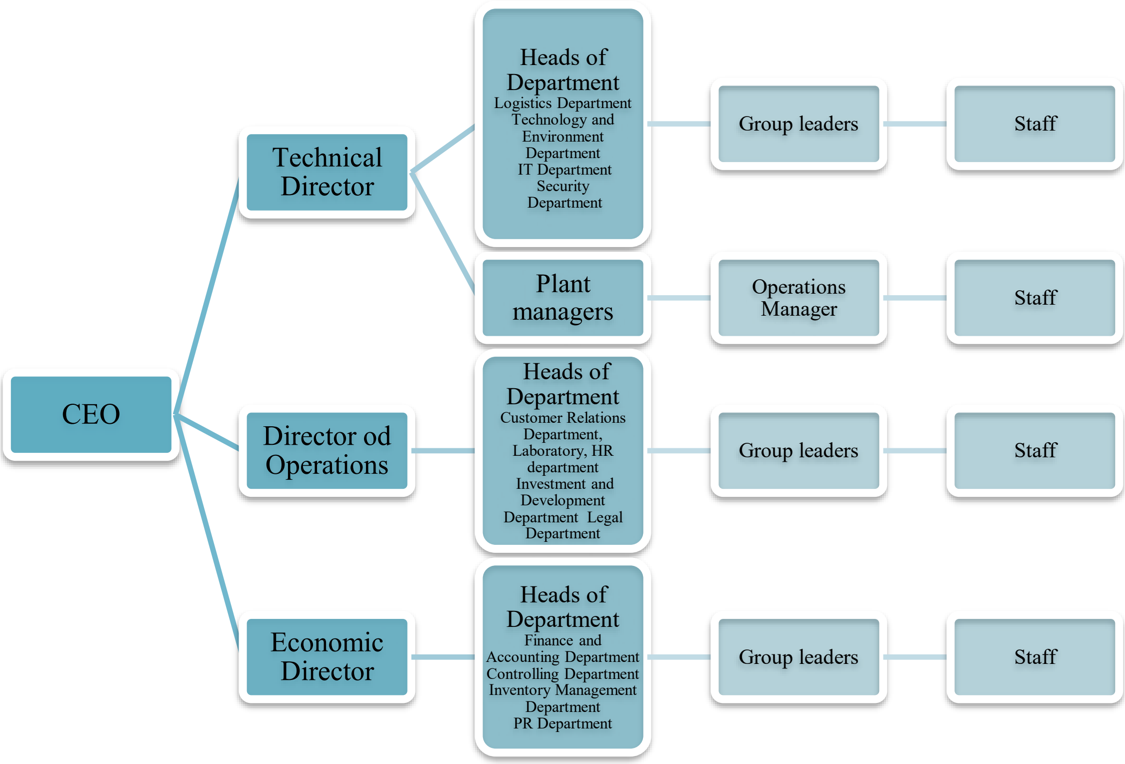

Figure 1
General organisational structure of water utilities

3. THE JOBS WE FOCUS ON IN OUR WORK

Water Engineer Staff

Staff Waterworks engineers play an extremely important role in the life of a water utility company. If we are talking about water production, then the process of purifying water to produce drinking water quality for the users must also be present. Waterworks engineers typically carry out their work within the operational area of the waterworks. Of course, not all water treatment plants have a full-time water treatment engineer on site, since the amount of water extracted, the capacity of the production plant, the amount of treated drinking water delivered to the network as required and the water treatment technology required determine the number of water treatment engineers needed at a given production plant. In this context, there are also sites, typically of smaller size and capacity, where water is produced but the system is remotely monitored, with the presence of a water engineer on site and the activities carried out intermittently or as required.

Based on the Central Statistical Office's Standard Classification of Occupations (FEOR-08), the occupations 3152 "Water, sewer and sewerage equipment operator" and 8322 "Water management machine operator" describe the tasks that water engineers perform in their work, as follows (Web_1, Web_2, Web_3).

In summary, water engineers are workers who perform independent activities in which they supervise and control the production, treatment and distribution of water in accordance with maintenance, repair and treatment instructions, in compliance with the applicable laws and regulations, and in accordance with the regulators of the operating unit.

Drinking water and waste water network maintenance workers

Drinking water and wastewater network maintainers start their work outside the boundaries of the drinking water and wastewater network; their tasks include the operation, maintenance, servicing, troubleshooting and restoration of the drinking water and wastewater network system between users and the sites in operation. According to the Central Statistical Office's FEOR-08 system, the job category and the related tasks are defined by the occupational category 7521 'Plumber (water, gas, heating)', which is as follows (Web_5).

The work of the drinking water and wastewater network maintenance staff is essential to ensure that the extracted and purified drinking water quality is delivered to the users and that the wastewater generated at the point of use is discharged and treated. For some water utilities, depending on the number of municipalities and users served, there are thousands of kilometres of network, including structures, manholes, booster stations and pumps, which network maintenance staff must monitor, maintain, repair and rectify faults at all times.

4. RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT ALLOWANCE SCHEME FOR JOBS

The provision of personal protective equipment to workers in the surveyed jobs is shown in Table 1.

Table 1
Personal protective equipment (PPE) provision scheme for the surveyed jobs

Job title:	**Water Engineer**		
Direction of protection	**Name of the protective device**	**Standard**	**Comment**
Head	Protective helmet	MSZ EN 397:2012+A1:2013	Vertical shock absorption, penetration resistance.
Eye	Safety glasses	MSZ EN 166:2003, F3	Stem sealed goggles.
Hearing organ	Ears, Earplugs	MSZ EN 352-1:2021, MSZ EN 352-2:2021	SNR value based on measurement.
Airways	Respiratory protection	MSZ EN ISO 136:2000	Respirators, full masks.
		MSZ EN ISO 14387:2021, Type B	Filter cartridge, against inorganic gases and vapours.
Hand	Protective gloves	MSZ EN 388:2016+A1:2019, 2422	Resistance to cutting.
	Protective gloves	ISO EN 511:2006, performance level 2	Against cold spread by flow or conduction.

	Protective gloves	MSZ EN ISO 374-1:2017 B	Protective gloves against chemicals.
Foot	Safety footwear	MSZ EN ISO 20345:2022, S1	Slip resistance, closed corner bark.
Test	Protective clothing	MSZ EN 14058:2018, Class I	Clothing to protect against cold environments.
	Protective clothing	MSZ EN 13034:2005+A1:2009, PB (Web_4)	Protective clothing against chemicals.
	Test harness	MSZ EN 361:2003	Full body harness.
	Rope	MSZ EN 354:2010	Anchoring ropes.

Job title:	**Sewage plant operator**		
Direction of protection	**Name of the protective device**	**Standard**	**Comment**
Head	Protective helmet	MSZ EN 397:2012+A1:2013	Vertical shock absorption, penetration resistance.
Eye	Safety glasses	MSZ EN 166:2003, F3	Stem sealed goggles.
Hearing organ	Ears, Earplugs	MSZ EN 352-1:2021, MSZ EN 352-2:2021	SNR value based on measurement.
Airways	Respiratory protection	MSZ EN ISO 136:2000	Respirators, full masks.
		MSZ EN ISO 14387:2021, Type B	Respiratory protection. Gas filters and combined filters. Filter cartridges against inorganic gases and vapours.
		MSZ EN 149:2001+A1:2009, FFP3 R	Against solid and liquid harmful dusts, fumes and aerosols.
Hand	Protective gloves	MSZ EN 388:2016+A1:2019, 3222	Nitrile gloves dipped to the wrist.
	Protective gloves	MSZ EN ISO 374-1:2017 B	Protective gloves against chemicals.
		MSZ EN 388:2016+A1:2019, 3222	Elongated, dipped gloves. Puncture resistance.
		MSZ EN ISO 374-5:2017	It protects against bacteria, fungi and viruses.
Body, Legs	Protective clothing	MSZ EN 14605:2005+A1:2009, Type 4	Protective clothing against chemicals. Exposure to liquid aerosol spray (pressure-free).
	Protective clothing	MSZ EN 14058:2018, Class I	Clothing to protect against cold environments.
	Test sling	MSZ EN 361:2003	Full body harness.

	Rope	MSZ EN 354:2010	Anchoring ropes.
	Safety footwear	MSZ EN ISO 20345:2022, S1	Slip resistance, closed corner bark.
	Rubber boots	MSZ EN 20345:2022, S6 MSZ EN 13832-1:2019, C	Slip resistance, water resistance, half knee boot.
Job title:	**Network maintenance**		
Direction of protection	**Name of the protective device**	**Standard**	**Comment**
Head	Protective helmet	MSZ EN 397:2012+A1:2013	Vertical shock absorption, penetration resistance.
Eye	Safety glasses	ISO 16321-1:2022, category A, N	High energy impact. Non-pairing lens.
	Safety glasses	MSZ EN 175:2003	Personal protective equipment. Eye and face protection for welding and allied processes.
	Safety glasses	MSZ EN 166:2003, F3	Stem sealed goggles.
Hearing organ	Ears, Earplugs	MSZ EN 352-1:2021, MSZ EN 352-2:2021	SNR value based on measurement.
Airways	Respiratory protection	MSZ EN 149:2001+A1:2009, FFP3 R	Against solid and liquid harmful dusts, fumes and aerosols.
Hand	Protective gloves	MSZ EN 407:2020, B 4	Against contact heat.
	Anti-vibration gloves	MSZ EN ISO 10819:2013	Equipped with vibration damping insert.
	Protective gloves	MSZ EN 388:2016+A1:2019, 2422	Against cuts and punctures.
	Protective gloves	MSZ EN ISO 374-1:2017 B	Protective gloves against chemicals.
		MSZ EN ISO 374-5:2017 (waste water)	It protects against bacteria, fungi and viruses.
	Protective gloves	ISO EN 511:2006 Performance level 4	Against cold spread by flow or conduction.
Foot	Safety footwear	MSZ EN ISO 20345:2022, S6	Closed heel cortex, energy absorption under the heel, full water resistance, puncture protection.
Body, Legs	Rubber boots	MSZ EN 20345:2022, S6 MSZ EN 13832-1:2019, C	Slip resistance, water resistance, half knee boot.

	Gasesuits	MSZ EN ISO 20345:2022, S5	Melles boots (gaiters).
	Visibility vest	MSZ EN ISO 20471:2020 EV Class 2	High visibility vest.
	Test sling	MSZ EN 361:2003	Full body harness.
	Rope	MSZ EN 354:2010	Anchoring ropes.
	Protective clothing	MSZ EN 13034:2005+A1:2009	Protective clothing against chemicals.
	Protective clothing	MSZ EN 1426:2007	Protective clothing. Protective clothing against infectious substances.
	Protective clothing	MSZ EN 14058:2018, Class II	Clothing to protect against cold environments. Resistance to water ingress.
	Skin protection product	-	Sunscreen cream with SPF 50 protection

5. GENERAL RULES FOR THE APPLICATION OF THE RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT ALLOWANCE SCHEME

The need for the provision of personal protective equipment, its definition and written documentation is stipulated for employers in Article 5 of Decree 65/1999 (XII.22) of the Ministry of Health and Social Affairs. The law also provides that the employer must lay down in writing other requirements relating to the continued use of protective equipment, such as the inspection, storage, replacement, maintenance and disposal of worn protective equipment as hazardous waste. Article 9 of the Act provides that the employer must involve the occupational safety and health representative and the occupational health service, who are entitled to make recommendations on the choice of protective equipment, when determining the arrangements for the provision of protective equipment.

An important factor in relation to the personal protective equipment benefit scheme is that the employer reviews the adequacy of the benefit scheme beyond a certain period. It must check the availability of personal protective equipment, its condition and its correct use on the basis of the records. If there is a change in the employee's work duties, the employee must be provided with personal protective equipment appropriate to his/her duties at all times. In addition, the extent and speed of wear of personal protective equipment must be monitored and, if justified, the necessary steps must be taken, which may involve the selection and use of other protective equipment with the necessary protective properties.

6. RECOMMENDATION FOR THE USE OF MORE INNOVATIVE PROTECTIVE EQUIPMENT

In this chapter, we would like to present personal protective equipment that incorporates a more innovative, innovative solution, the possible use of which could potentially provide a more effective and higher level of protection for workers involved in water utility services, beyond the minimum requirements for personal protective equipment.

Automatic life jacket

The use of an automatic lifejacket as personal protective equipment may be justified for water and wastewater operators who carry out inspection or other activities on certain works and machinery. Their activities may be carried out in open, deep water, e.g. reservoirs, storage basins, or near derricks or basins where sewage is present (Web_6). The automatically inflating lifejacket is activated as soon as water reaches the sensor inside, which causes the vest to inflate within 5 seconds of water reaching it. This significantly increases an individual's chance of survival if they are incapacitated while falling into the water, i.e. in this case, they may be in a state of unconsciousness. Features of the vest include being brightly coloured, fitted with a safety whistle, and having a tube to blow air into the vest to replace escaping air.

Multi-gas detector

The use of a personal gas detection detector may be justified for wastewater network maintenance and wastewater plant operators due to their job duties. In the case of work where sewage and the resulting hazardous gases may be present, airborne detection devices are used to ensure that the boarding operation can be started and is safe. However, we know that the distribution of gases is generally not uniform, so there may be situations and places where, precisely where the worker is present, dangerous gases are present in high concentrations. For this reason, a personal gas detector can offer a higher level of protection for the worker, as it provides a continuous and local measurement during the work (Web_7).

There are also gas detectors on the market that are equipped with a motionless sensor and wireless communication, which can be connected to smartphones (iOS, Android) via Bluetooth.

Noise protection earplug ear muffs

The operation of water utilities, both in enclosed and open spaces, generates noise impacts against which workers need to be protected. An important factor, however, is the use of noise protection equipment that actually filters out and reduces those noises and sound effects that are disturbing, harmful and unnecessary, but that ensures and improves speech understanding, so that the understanding of certain hazards and work instructions is ensured and adequate (Web_8).

There are noise ear moulds that are made on the basis of an impression, which, due to their anatomical accuracy, provide the wearer with the right comfort and noise protection. An example of such a device is the Passguard-H noise earplug, which is made of a special anti-allergenic silicone alloy. It is recommended for use in industrial noise attenuation in industrial installations, where speech intelligibility is ensured, with an average noise attenuation of 37 dB.

Heatable jacket

Workers in water utilities are very often exposed to the weather. Whether we are talking about troubleshooting and supervision, on-boarding or securing, or operating technology. It is not always the case, but it does happen that workers work in a cold environment for long periods of time while being exposed to light physical stress, and then naturally the feeling of warmth in cold weather gradually decreases. The situation is similar in technological spaces where cold, flowing media are present, which reduce the sensation of heat even more. It is advisable to provide workers with heated jackets to reduce the stresses and strains of a cold working environment.

The jacket features three heating panels that work at critical points on the body. The jacket is powered by a rechargeable battery and can be charged via USB. The built-in controls allow the wearer to switch between three heat settings: high, medium and low. The heated panels provide temperatures between 25-45°C for up to 10 hours. Additional features include waterproof fabric, insulated seams for enhanced water and wind resistance, elastic cuffs and drawcord adjustability for a snug fit. Certified to EN ISO 20471.

Portable long jib crane system

In the water and wastewater sector, the safety of on-boarding operations is a key issue. In the water utilities sector, due to the technological characteristics and the design of the utilities, there are many instances of boarding operations that can occur at almost any point within the service area (interceptors, manholes). It can be argued that not always is fixed equipment available that would allow the safe evacuation of the boarding worker, and it is therefore advisable to provide the teams with portable long jib crane systems that allow this.

Stapling system

One of the most common accident risks for workers in water utilities is injuries from tripping and falling on foot, getting in and out of vehicles, and from terrain. To ensure that safety footwear provides adequate ankle support and thus greater stability, it is advisable to use a lacing system that provides an excellent fit and firm support. A good example is the Boa® Fit System lacing system (see Figure 2), which can be adjusted by means of a dial to ensure an optimal fit at all times. Its simple design allows one-handed adjustment without removing gloves. The corset is made of lightweight, yet extra strong stainless steel and nylon threads, which are resistant to oil, water and other mechanical stresses. The closed lacing system means it can never come loose or get caught on anything, providing a stable grip while improving circulation in the foot by eliminating the pressure points experienced with traditional laces (Web_9).

Figure 2
Boa® Fit System corset system (Web_9)

7. SUMMARY

In the case of a water utility company, there are significant geographical distances, a large service area, a large number of work activities and a large number of employees. Checking that personal protective equipment is being used as intended by the workers is a huge, sometimes physically impossible, task for their direct supervisor.

There are safety systems - such as AIM2 PPE Monitoring - that monitor the safety of workers in real time, sending alerts and periodic reports on possible safety violations and dangerous situations such as the removal of mandatory PPE or excessive access to restricted areas. Naturally, these solutions are mainly implemented in installed workplaces. AIM2 PPE Monitoring works by installing intelligent cameras at fixed or mobile points in the environment to be monitored. These cameras monitor features, are able to extract events related to PPE from video analysis. There are also solutions that allow or deny access to restricted areas of industry before work starts, similar to an access gate [12].

The adaptation of personal protective equipment monitoring to the water utilities sector is justified, but would be extremely complex to implement. As a first step, it would be advisable to establish a database of the personal protective equipment required by workers, by article number, according to the order in which the equipment is distributed, in order to keep up-to-date the exact characteristics of the personal protective equipment issued to the worker. In the case of water and wastewater engineers, this could be considered a deployed workplace, but in the case of network maintenance workers, almost certainly not, an access gate system could be used when they leave the base with their vehicles to carry out the current repair work.

The use and proper application of personal protective equipment is of utmost importance for both workers and employers. On the workers' side, to protect their health and ensure their income and livelihood, and on the employers' side, to avoid penalties, loss of money and time, and to maintain a good reputation by ensuring that the workplace is designed to create and support health and safe working conditions at all times.

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MODERNISATION OF THE MANAGEMENT OF OILY LIQUID WASTE AND ITS OCCUPATIONAL SAFETY IMPLICATIONS

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Abstract: In the view of the steady increase in the volume of oil-containing liquid wastes and emulsions, waste management companies must have advanced technologies, vehicles and equipment to transport and treat these wastes. If oil-containing wastes are directly discharged to land, they can pose a significant environmental and social risk if they reach groundwater, possibly drinking water sources, and contaminate them. The aim of our work is to investigate the possibility of introducing a new technology for the treatment of emulsions, analysing and evaluating the risks to occupational safety and health, using a concrete example. Activities related to the treatment of oily waters, oily sludges and emulsions will be presented and analysed in terms of their potential for improvement. Based on a review of a few selected technologies, a detailed analysis of the deployability and occupational safety aspects of the selected emulsion removal equipment for the treatment of emulsions will be carried out.

Keywords: *liquid waste, BET, vacuum distiller, EHS*

1. INTRODUCTION

According to the data published by the Hungarian Central Statistical Office (KSH), the number of road vehicles in Hungary has increased significantly over the last decade. The largest increase is in the number of passenger cars, which rose from nearly 3 million in 2012 to nearly 4 million by the end of 2022, but the number of trucks also increased significantly from nearly 415,000 to 570,000 over the decade.

As the number of road vehicles, and thus vehicle traffic, has grown considerably, more and more car and truck washes have been set up across the country. It is estimated that nearly half of the passenger car fleet is cleaned by operators in manual or mechanised car washes, while the other half is typically washed at home. The cleaning of lorries and trucks is typically carried out in truck washes and truck wash facilities capable of accommodating such large vehicles.

Car washes are operated using surfactant-based detergents to ensure that the water used for washing can remove dirt from the surface. During washing, the water is contaminated with emulsifying agents. Emulsion recovery can only be achieved by flocculation and emulsification (Nagy et al., 2022).

Contaminants may include engine oil, lubricating oil, dust, sand, brake pad dust, tyre shreds, etc. that may leak from vehicles. Sludge and water contaminated with oil from car washes is collected in underground tanks, but the collected material requires further treatment. With the increasing use of water for washing purposes, more and more emulsions and effluents are being generated that could pose a risk to the environment or nature conservation.

In addition to wastewater from car washes, there are also significant volumes of oily sludge and cooling emulsions from certain metalworking technologies, where these are collected locally in closed drums and IBCs until transfer to treatment.

The above-mentioned wastes are classified as hazardous waste requiring special treatment pursuant to Act CLXXXV of 2012 on Waste, and their treatment can be carried out in accordance with the provisions of Government Decree 225/2015 (VIII. 7.) on the detailed rules of certain activities related to hazardous waste.

2. INTRODUCTION TO VACUUM EVAPORATOR TECHNOLOGY

2.1. Main features of the technology

Vacuum distillation is a technique used to separate the components of a mixture at reduced pressure. The technology is based on the evaporation of the material, so that water or distillate can be recycled back into the production process. One of the most commonly used methods for the separation of liquid mixtures is the vapour-liquid equilibrium distillation (Web_1).

The most common are heat pump heated vacuum evaporators. In vacuum systems, the material to be compressed is sucked into the evaporator by low pressure. The cooling circuit, which uses a built-in heat pump, is able to simultaneously provide heat to the liquid being processed and cool the vapour produced during boiling. The distilled liquid and processed residue are removed at the end of the distillation process.

Another grouping: vacuum evaporators - with additional equipment:

- vacuum evaporators heated by hot water or steam,
- evaporators with internal heat exchanger and wiper / heat exchanger with grating,
- evaporators with external heat exchanger,
- multiple-efficiency vacuum evaporators.

There have been several studies on vacuum evaporators. A.M. Goldman (1985), who designed an ultra-high vacuum evaporation system using a molecular beam source and surface analysis (the analysis was performed by electron spectroscopy (AES) and reflection high energy electron diffraction (RHEED)), investigated the low temperature measurement capability of the ultra-high vacuum evaporation system.

Around the world, several countries are involved in the treatment and phase separation of emulsions and the manufacture of these systems. I will highlight the following:

Sonic Corportation is based in the United States and manufactures complete systems in-house. These systems are custom made. The principle of operation is that each system uses PD pumps and flow meters, which simultaneously measure and mix different liquids according to the values specified in the different formulations, and these are fed into a mixing device. PID pump control is based on the flow meter, which ensures the required proportions between the components. The PLC function is the heart of the system, ensuring the operation of all the pumps and controlling them according to the prescribed ratios. The instruments monitor pH and conductivity (Web_2).

The Ginhong Company, a company based in China, manufactures equipment with very high quality materials and accessories. In addition to manufacturing, they are also involved in the installation and maintenance of the equipment, in which they have a great deal of experience. The RX Vacuum Homogenizer Mixer has a capacity from 50 litres to 500 litres. This is the equipment that processes viscous emulsions. A stainless steel YX Vacuum industrial mixing tank can be connected to the homogenizing mixer to process low viscosity emulsions (Web_3).

The Formeco Italian Company was founded in 1971 and has installed more than 40 000 machines worldwide, making it a world-renowned company. The equipment is suitable for the treatment of waste water, emulsions and solvents. Formwork emulsion treatment units combine heat pump and vacuum evaporation technologies to maximise yields with low energy investment. Under vacuum, the heat pump technology reduces the boiling point of the water to 35-40°C, the same circuit is used for heating and condensation, thus significantly reducing the energy required. The process separates the water from contaminated products such as oils and fats. It produces high quality pure distilled water and reduces the amount of liquid concentrate. This low energy system results in power consumption that is seven times less than conventional atmospheric distillation. An added benefit is that the water can be reused. There is no need for a pump to fill the liquid waste or to discharge the treated clean water. With the touch screen PLC, it is easy to set all the functions and faults can be quickly identified. It features a special design with low noise during operation (Web_4).

In Hungary, there is a newly developed device that electrochemically separates the oil and removes the colloids. It reduces the colloid content of wastewater to below 5 mg/liter (5 ppm) and improves other properties of the water. In addition, there are several more well-known vacuum distillation devices: e.g. H_2O VACUDEST (Web_5), type HDV 632 (Web_6), and the EVT-DESTOMOIBIL (Web_7) vacuum distillation device.

Several similar devices were reviewed, their main parameters were taken into account, and the following K-VAP 800 vacuum evaporator was selected to investigate its integration into the existing technology.

2.2. Selection criteria

The following criteria were decisive for the selection of the machine: based on the company's current liquid waste supply, the ideal evaporation capacity of this machine is 800 l/h. The heating time of the unit is also favourable, close to 4 hours, and the space requirements (length: 4.6 m x width: 2.5 m x height: 3.6 m), which can be provided on site, were also a factor in the selection.

After the sludge waste has been discharged at the site, the liquid waste is passed through a circular filter and then through a perforated vertical filter. Two main workers are involved in these operations, one is the driver and the other the operator. Compared to older technologies, the discharge is no longer into IBC containers but into a basin, thus reducing the risks at the workplace. There is a risk of spillage if the connection of the stub is inadequate. The process of the technology is shown in Figure 1.

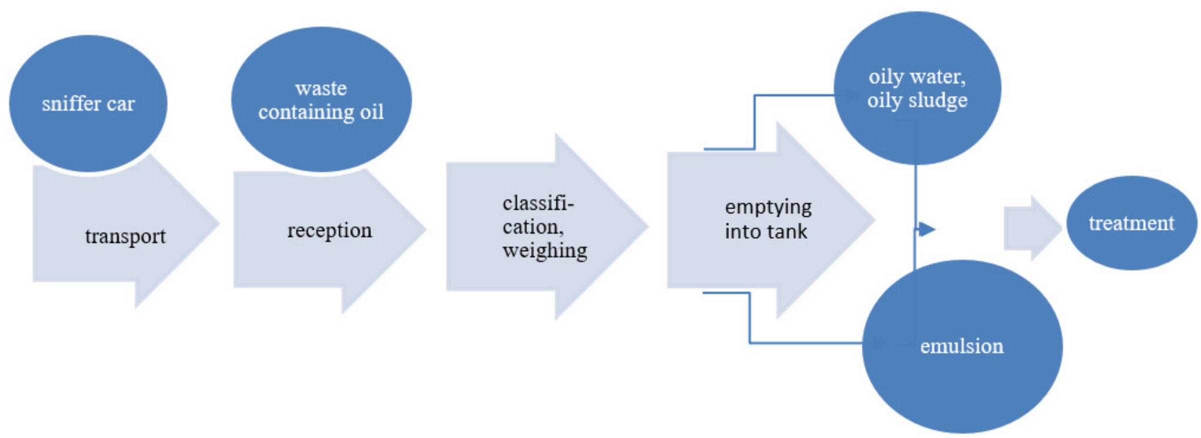

Figure 1
Hazardous liquid waste processing flow diagram

In the case of deliveries, the acidity of the liquid wastes (e.g. oily water, waste water, oily sludge, paint water) delivered must always be tested. In addition, it is forbidden to discharge flammable, volatile or explosive substances into the installation.

In case the pH of the incoming water is less than 7, it will damage the operation of the vacuum evaporator under test and the equipment should be drained. The chances of this happening are low because in all cases the laboratory results are sent before delivery.

After the above processes, the sludge that has passed through the filter is pumped into a 50 m3 standing buffer tank. From there, it is pumped through a (micro)fine filter by a manually operated petrol engine pump and finally into the final stationary tank, where the sludge to be treated spends 24 hours. From here the process is automated. The dosing is set at the control cabinet of the vacuum evaporation unit, which is fed from the last tank into the unit. The equipment's task is to evaporate the water from the material to be concentrated, producing a concentrate of water-poor, water-soluble components of the raw material. The extracted water vapour is partly condensed on the heating heat exchanger and the condensate is discharged, and partly recycled to the circulating liquid. In this way, the emulsion can be further concentrated.

How much emulsion you want to compress can be adjusted with the pneumatic reducer on the front of the control cabinet. Check the purity of the condensate by measuring its conductivity. The residual concentrate is discharged in stages into a drain. There is a similar relationship between the evaporation capacity of the condenser and the concentration of the material. Dewatering can also be controlled on the basis of minimum power. Maximum concentration can be ensured by reducing the evaporation water volume to zero. Once the concentrate has been discharged, the evaporator level decreases and fresh material is automatically fed in, increasing the output and reducing the concentration. The optimum should always be sought when adjusting the discharge.

2.3. Operating principle of the equipment

Pressing the "start" button on the vacuum evaporator opens the valves and starts the compressor. The pumps then operate automatically during the filling phase. When the circulation is stable, the heating starts. The injected water vapour and the circulated air together heat up the circulating liquid. During heating, the vapour under pressure transfers heat by condensation to the circulating liquid. The condensate is discharged into the buffer tank. During operation the evaporator is 90-120°C. When the heating reaches 99°C, the unit switches to production. From then on, condensation is continuous. At emulsion, an equilibrium state is automatically reached, where the system heats and produces at the same time. This is also controlled by a pneumatic valve located on the control cabinet. When the set concentration is reached and the set volume is ready, it is discharged through the heat exchanger.

Feeding can be set with the operating parameters. Feeding can be continuous or one-off. It is important to note that there is no loading during the unloading. The last step is shutdown, when the intake valve and the outside air cool down the inside of the blower. The unheated liquid in the condensate cools down, the pump stops and the equipment stops. The preheated and cooled heat exchangers are drained by the operator by manual control. At the end of the discharge, the residual material in the preheated system shall be discharged manually.

3. OCCUPATIONAL HEALTH AND SAFETY RISK ASSESSMENT

Based on the above processes and the hazards associated with each job, and taking into account the information available, the jobs examined are classified by area and by hazard, as shown in Table 1. The risk assessment, based on an examination of the risks encountered, identified the sources of risk as shown in Table 1.

Table 1
Work processes, breakdown by hazards, risks

Serial number	New workflows	Endangered	Identifying sources of risk
1.	Waste transport	Vehicle driver,	Non-functioning superstructures on vehicles, careless work
2.	Retrieved from	Driver, operator	Careless work, risk of spillage, lack of maintenance, risk of slip-ping
3.	Treatment	Manager	Working without protective equ-ipment,
4..	Chemical dosage	Manager	Working without protective equ-ipment, spillage of chemicals, use of inappropriate chemicals
5.	Feeding	Handler, unskilled worker	Compressed sludge spillage, working without protective equ-ipment

After identifying the sources of risk, we assessed the different risk factors and examined ways to mitigate the risks.

4. CHEMICAL RISK ASSESSMENT

The steps of the chemical risk assessment were carried out on the basis of the Guide for conducting workplace risk assessment published in 2010 (Ministry of Innovation and Technology, Department of Occupational Safety and Health (2021)), where the requirements of ITM Decree 5/2020 (II. 6.) were taken into account and the risks arising from the work activities in the assessed areas were determined for the company

Safety data sheets for the chemical hazardous substances and preparations to be used in the new technology have been reviewed. For the chemical risk assessment, the provisions of the Decree of the Ministry of Economy and Labour 44/2000 (XII. 27.) on the detailed rules of certain procedures and activities related to dangerous substances and dangerous preparations and the Decree of the Ministry of Economy and Labour 5/2020 (II. 6.) on the protection of the health and safety of workers exposed to chemical agents were taken into account.

5. COMPARATIVE ASSESSMENT OF THE OHS RISKS OF AN OLDER TYPE AND THE IMPROVED TECHNOLOGY, PROPOSAL FOR RISK MANAGEMENT AND RISK REDUCTION

The following is a comparative assessment of the OHS risks of an older type of technological process (based on the patent specification of the so-called OTH 3277/84) and the improved technology. The results of the comparison are presented in Figure 2, broken down by activity.

The first activity examined is the transport of waste (1.) The hazards here are typically due to inattention, which can endanger the physical safety of workers. Although the level of risk is low for both the older technology and the extended technology, the rules of the road should be clearly set out in writing. Drivers should receive training (external contractors, own drivers), including on reversing, machinery blind spots and collision hazards. As the transport of hazardous liquid waste is mainly carried out by means of a siphon truck, ADR rules should also be given high priority.

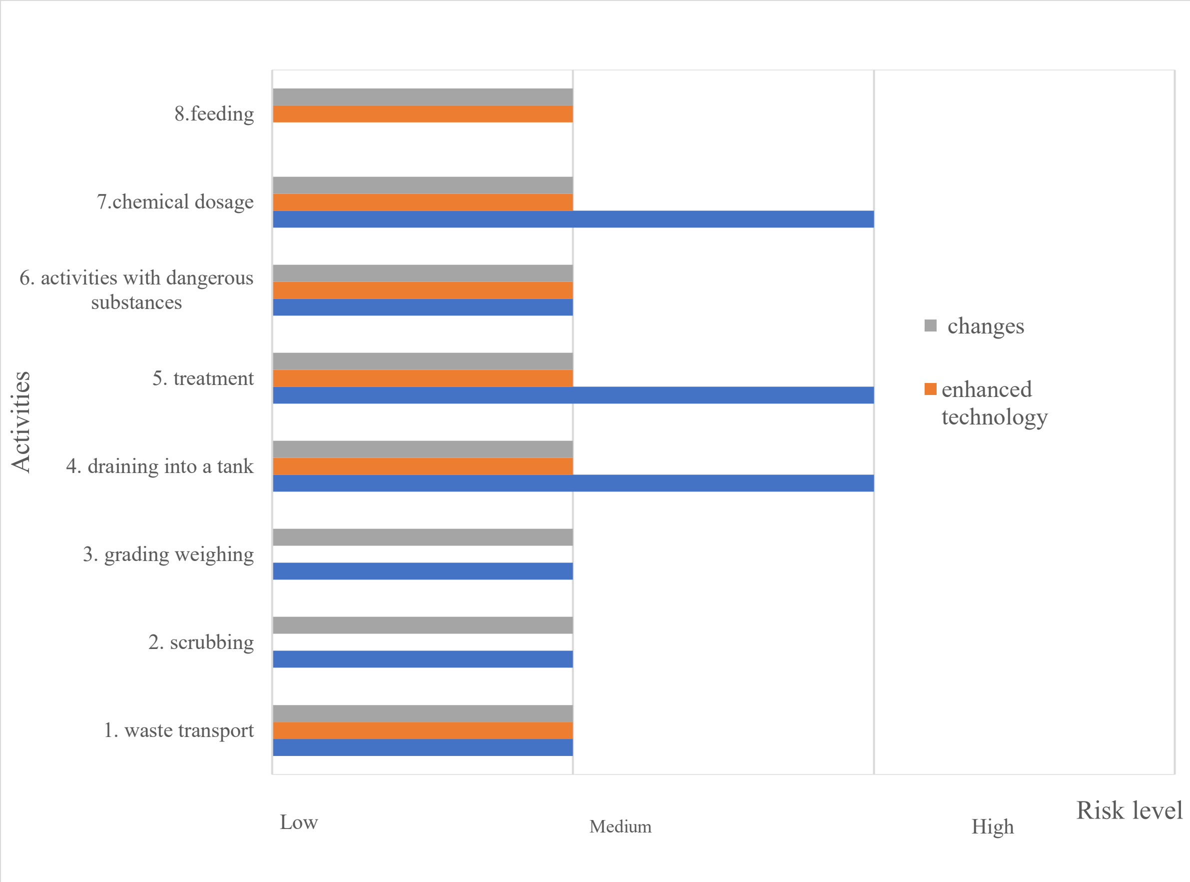

Figure 2
Comparison of occupational health and safety risks of existing and enhanced technology

The next activity under consideration is material handling (2.) The table shows that this activity is not present in the extended technology. In the case of the older technology, tipping, sliding, falling apart may be present during loading. Furthermore, if the incoming waste arrives in IBCs or ADR-certified drums, mechanical damage may occur during handling due to sharp, jagged surfaces. With occupational health and safety training and appropriate personal protective equipment, accidents can be avoided and their risks minimised. In this respect, it is clear that the enhanced technology is significantly more favourable because the resulting risks are not present.

The next activity under consideration is the classification and weighing (3) of the incoming hazardous liquid waste. As in the case of material handling, it can be seen that this activity is not present in the technology for the extended technology. Mechanical damage may occur during the transfer due to non-compliance with the rules.

Discharge into the tank (4) raises several medium-level sources of risk for existing technology. One is wet weather treatment, where there is a medium risk of electrocution when working under current. This can be avoided with appropriate training and awareness raising. As the operator has to climb up a ladder on the tank wall when discharging liquid waste into the tank farm, falls are a potential hazard from working at height. Sludge-like wastes deposited at the bottom of the tanks must be cleaned out periodically after the tanks have been emptied. This is a medium risk as vapours and gases may be released. With the extended technology, the risk levels are significantly lower, as there is no working at height and the risk of falling is eliminated. With the extended technology, the discharge is at ground level through a discharge pipe, so there is no need to clean the tanks.

In the case of treatments (5), the older technology under consideration has a much higher risk of treatment than the extended technology because of the exposure that could pose a biological hazard to workers. These can be avoided by appropriate vaccination. These vaccinations are: against tetanus, typhoid, hepatitis A and hepatitis B. The level of risk from the use of chemicals is the same for both existing and expanded technology. The use of personal protective equipment is compulsory.

Hazardous substances activities (6) are characterised by monotony, workplace stress, the pressure of work and the management of human relationships in the workplace. This can be addressed through regular training and appropriate rotation of work processes. The risk levels are the same for both processes. There are also biological hazards, which can arise from the risk of infection. They can be avoided by vaccination as described above.

For the chemical dosing activity (7), the operator must prepare the chemicals used in the treatment according to the recipe for the older technology. Personal protective equipment must be used. The risk of chemical dosing is much lower with the extended technology, as the dosing is done through an automated system. This eliminates the risk of skin and eye injuries.

Feeding (8) is a new workflow, only appearing in the extended technology. Here, mechanical injuries caused by work tools due to inadequate work discipline may be an emerging risk due to sharp, jagged parts. The connection of the discharge stub is located on the ground. The risk level is low risk.

6. FINDINGS, CONCLUSIONS, SUMMARY

A technology that was used in the past (based on the patent specification of the so-called OTH 3277/84) was reviewed above, and then the safety and chemical risks of the associated work processes were also examined and stratified, taking into account the parameters of a modern vacuum evaporation plant. The risks identified for the older technology were compared with the risks identified for the improved technology, and the results are presented in a diagram and text. Based on the results of the analysis, the following findings and conclusions can be drawn:

- For waste transport, the risk levels are low for both technologies. Regular training of drivers can reduce the risks from transport.
- For material handling, this activity is not present in the extended technology. In the case of the older technology, mechanical injuries can occur during loading and material handling due to sharp, jagged surfaces, but these accidents can be avoided with personal protective equipment, the level of risk is low. Expanded technology is significantly more favourable, as the risks involved are not present.
- In the case of classification and assessment, this activity is not present in the extended technology, and the level of risk is low in the older technology. Mechanical damage can occur during the transfer due to non-compliance with the rules.
- Several medium-level sources of risk can be identified in the case of tank dumping compared to existing technology. The first is working under power, the risks of which can be avoided through training and awareness raising. The second is during the discharge when the operator is climbing up the tank wall, so the risk is from falling and working at height. The third is occasional tank cleaning, which is a medium risk because of the release of vapours and gases. With the extended technology, the aforementioned risk levels are low because there is no working at height and the risk of falling is eliminated. With the extended technology, the discharge is made on the ground through a discharge pipe, so there is no need to clean the tanks.
- The treatments present a higher (medium) risk than the older technology because there is exposure that could pose a biological hazard to workers. These can be avoided by

appropriate vaccination. The level of risk from the use of chemicals is the same for both technologies.

- The identified hazards of working with hazardous substances include monotony, work stress, the pressure of work, and the management of human relationships in the workplace. Risk can be avoided through training and proper rotation of work processes. Risk levels are the same for both processes and are low. Biological hazards are also present, which may arise from the risk of infection, but can be avoided by appropriate vaccination.
- The chemical dosing activity for the older technology requires the operator to mix the chemicals used in the treatment based on the formulation, therefore the level of risk is medium. In the case of the extended technology, the risk of chemical dosing is lower, low, as the dosing is done through an automated system. This eliminates the risk of skin and eye injuries.
- The outfeeding activity is a new workflow, present only in the extended technology. Mechanical damage due to sharp, jagged parts can result from inadequate work discipline. The connection of the discharge stub is located on the ground. The risk levels for these activities are low.

Overall, the proposed improvements to the technology do not pose any additional risks to workers from an OHS perspective.

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