VÉDELEM TUDOMÁNY
KATASZTRÓFAVÉDELMI ONLINE TUDOMÁNYOS FOLYÓIRAT

József Dobor, György Pátzay, Nóra Szűcs-Vásárhelyi, Kálmán Serfőző, Balázs Barina

ENVIRONMENTAL POLLUTION RESULTING FROM HAZARDOUS PLANT POLLUTION, ITS CHARACTERIZATION FROM A DISASTER MANAGEMENT POINT OF VIEW, AND A SUMMARY OF THE LESSONS LEARNED FROM THE CASE

Abstract

The aim of the authors of the article is to present their present research, which provides an alternative to the legal regulation that can be used, in addition to the methods and tools that can be used to determine the causes, causes and possibilities of soil pollution. The authors conduct research in a variety of disciplines, examining environmental elements, the legal regulation of hazardous plants, chemical technology, and primary intervention. Thus, they present the same problem from different angles. In any case, the industrial origin of soil contamination can also be reduced by legislation. This is worth highlighting because soil contamination is a complex and costly tool to detect, analyze, and prevent contamination. At the beginning of the article, we present a model experiment planned for our research in a few months. We then perform a complex presentation of soil contaminants based on the available international literature. We then describe the legal regulatory option, listing the most recent regulators. Finally, as a summary, we conclude our summary with a few figures. Our presented research is planned to last for several years, and our results are continuously published on possible scientific platforms.

Keywords: soil pollution; disaster management; industrial safety; legislation

EGY LEHETSÉGES TALAJSZENNYEZÉSSEL JÁRÓ, VESZÉLYES ÜZEM ÁLTAL OKOZOTT KÖRNYEZETSZENNYEZÉS RÖVID, KATASZTRÓFAVÉDELMI SZEMPONTÚ JELLEMZÉSE ÉS AZ ESETBŐL ADÓDÓ TANULSÁGOK ÖSSZEFOGLALÁSA

Absztrakt

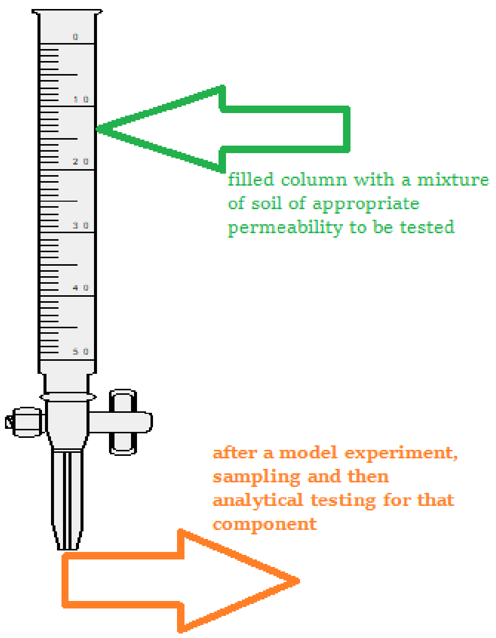
A cikk szerzőinek célja, hogy bemutassák jelen, folyamatban levő kutatásukat, amely a talajszennyezés okainak, folyamatainak meghatározására alkalmazható módszerek és eszközök mellett alternatívát kínál az alkalmazható jogi szabályozáshoz. A szerzők különféle tudományterületen végeznek kutatásokat, vizsgálva a környezeti elemeket, a veszélyes üzemek jogi szabályozását, a vegyipari technológiát és az elsődleges beavatkozási lehetőségeket veszélyes anyagokkal kapcsolatban bekövetkezett eseményeknél. Így ugyanazt a kérdést különböző szögekből mutatják be. Mindenesetre az ipari, mezőgazdasági eredetű talajszennyezés kialakulásának lehetősége mérsékelhető alkalmas jogi szabályozásokkal, mint ahogy a cikk adott részében ezt a szerzők alátámasztják. Ezt azért érdemes kiemelni, mert a talajszennyezés észlelésére, elemzésére és megelőzésére meglehetősen költséges eszközök, módszerek és munkaórák szükségesek. A cikk elején bemutatjuk a kutatásunkhoz tervezett modellkísérlet egy vázlatát. Ezután a rendelkezésre álló nemzetközi szakirodalom alapján a talajszennyeződésekkel kapcsolatban fogalmazzuk meg a kutatásunkhoz szükséges alapokat. Ezután ismertetjük a jogi szabályozási lehetőséget. Összefoglalásként eredményeinket ábrák segítségével ismertetjük. Bemutatott kutatásunk a tervek szerint több évig fog tartani, eredményeinket folyamatosan közzétesszük a lehetséges tudományos platformokon.

Kulcsszavak: talajszennyezés, katasztrófavédelem, iparbiztonság, jogi szabályozás

1. INTRODUCTION

Hungary's chemical industry has achieved significant results in the last century, but even today the success in this professional field is tangible. One of the areas of the chemical industry with a significant driving force is the pharmaceutical industry, the economic characteristics of which are seriously related to the GDP of Hungary. The chemical industry accounts for about 18-20% of total industrial production (including the oil, gas and plastics industries, among others). The chemical industry produces products that are essential to our standard of living through operations involving hazardous activities and the use of hazardous substances. [1-3]

The model experiment can provide information on the efficiency of the detection of the given components, in our case heavy metal ions, from the soil. The described option is published based on the authors' idea, so it is their own idea. Of course, the process must be repeated several times and the method must be tested at the very beginning, with a known amount of components.



A charged model column is designed for the experiment. The column can be filled with soil samples of different permeabilities, even mixed with an artificial part (debris, concrete). The permeability of the charge is optimal if it can pass a minimum of 1 cm^3 of solution per minute.

parameters	**Ni^{2+}**	**Hg^{2+}**	Cd^{2+}	Cu^{2+}	Zn^{2+}	Cr^{3+}
c [mol/dm^3]	**0.05**	**0.005**	**0.005**	**0.02**	**0.05**	**0.005**
flow [cm^3/min]	**0.1**	**0.01**	**0.01**	**0.01**	**0.1**	**0.01**
pH of solution	**5.0**	**6.0**	**5.5**	**6.0**	**6.0**	**4.5**

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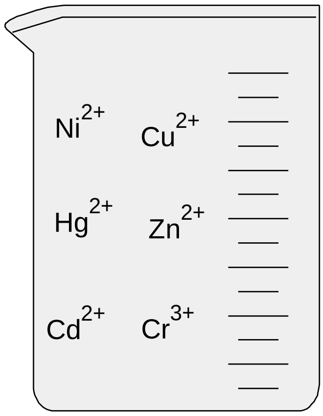

Laboratory measuring equipment (eg. ion chromatograph, atomic absorption analysis) is suitable for the analysis of samples. A water-soluble heavy metal compound to be used in the experiment. Subsequently, the heavy metal contamination of the embankment (the modeled soil of the industrial zone, built environment) should also be determined by analytical analysis.

Figure 1. Design plan for a model experiment to investigate heavy metal contamination in soil (Figure drawn by the authors, using the program below: ACD/ChemSketch (Freeware Version), ACD/Labs 2016.2 (File Version C30E41, Build 90752, 20 Dec 2016) [by authors]

2. SOIL POLLUTION

The contaminant may enter the soil as a result of either natural or anthropogenic activity. Elements and compounds already present in the environment can be released into the soil as a result of natural processes, but also during disasters (volcanic eruptions, floods, earthquakes, cyclones, etc.). These contaminants come mainly from sediments and rocks that dissolve in groundwater and accumulate in aquifers and are then pumped for consumption. A well-known example of this is arsenic, the high concentration of which in groundwater bodies is also a problem in Hungary [4]. However, a much higher proportion of harmful substances enter the soil due to human activity. We would like to present this in more detail in the next part of the article.

1.1 The major types of soil pollutants

As a result of industrialization, we now use thousands of different chemicals in our daily lives, which can be dangerous to humans and the environment. In the case of pollution, it does not matter how much of a given substance enters the soil, what the physical, chemical parameters of the soil are, etc., because many compounds only become dangerous above a certain concentration [5]. The most important of these substances are ranked according to human toxicity, bioaccumulation, persistence, exposure and frequency by the United States Environmental Protection Agency (EPA) and, in the European Union, the European Chemicals Agency (ECHA). These compounds pose an increased risk to human health because they are toxic or do not degrade or degrade over a long period of time, so they persist in the soil and easily accumulate in body tissues. Table 1 lists the Persistent Organic Pollutants (POPs) covered by the POPs Regulation. The full list and regulations for other hazardous substances are available at www.echa.europa.eu and http://chm.pops.int/ [6-7].

Category	Substance name	EC / List no	CAS no	Date of inclusion in the POPs Regulation	POPs Regulation Annex
○	Aldrin	206-215-8	309-00-2	29/04/2004	Annex I, part A Annex IV
	Alkanes, C10-13, chloro	287-476-5	85535-84-8	19/06/2012	Annex I, part A Annex IV
	Bis(pentabromophenyl) ether	214-604-9	1163-19-5	20/06/2019	Annex I, part A Annex IV
○	Chlordane, pur	200-349-0	57-74-9	29/04/2004	Annex I, part A Annex IV
○	Chlordecone	205-601-3	143-50-0	29/04/2004	Annex I, part A Annex IV
	Clofenotane	200-024-3	50-29-3	29/04/2004	Annex I, part A Annex IV
○	Dicofol	204-082-0	115-32-2	18/08/2020	Annex I, part A
○	Dieldrin	200-484-5	60-57-1	29/04/2004	Annex I, part A Annex IV
	Dodecachloropentacyclo[5.2.1.02,6.03,9.05,8]decane	219-196-6	2385-85-5	29/04/2004	Annex I, part A Annex IV
○	Endosulfan and its isomers	-	-	19/06/2012	Annex I, part A Annex IV
○	Endrin	200-775-7	72-20-8	29/04/2004	Annex I, part A Annex IV
	Heptabromodiphenyl ether	-	-	24/08/2010	Annex I, part A Annex IV
○	Heptachlor	200-962-3	76-44-8	29/04/2004	Annex I, part A Annex IV
▲	Hexabromo-1,1'-biphenyl	252-994-2	36355-01-8	29/04/2004	Annex I, part A Annex IV
▲	Hexabromocyclododecane (HBCDD)	-	-	01/03/2016	Annex I, part A Annex IV
▲	Hexabromodiphenyl ether	-	-	24/08/2010	Annex I, part A Annex IV
○ ▲ ■	Hexachlorobenzene (HCB)	204-273-9	118-74-1	29/04/2004	Annex I, part A Annex III, part B Annex IV
▲ ■	Hexachlorobuta-1,3-diene	201-765-5	87-68-3	19/06/2012	Annex I, part A Annex III, part B Annex IV
○	Hexachlorocyclohexanes, including lindane	-	-	29/04/2004	Annex I, part A Annex IV
	Pentabromodiphenyl ether	-	-	24/08/2010	Annex I, part A Annex IV
○ ▲ ■	Pentachlorobenzene	210-172-0	608-93-5	24/08/2010	Annex I, part A Annex III, part B Annex IV
○	Pentachlorophenol and its salts and esters	-	-	20/06/2019	Annex I, part A
○ ▲	Perfluorooctane sulfonic acid and its derivatives (PFOS) C8F17SO2X, (X = OH, Metal salt (O-M+), halide, amide, and other derivatives including polymers)	-	-	24/08/2010	Annex I, part A Annex IV

▲	perfluorooctanoic acid (PFOA), its salts and PFOA-related substances	-	-	15/06/2020	Annex I, part A
▲ ■	Polychlorinated biphenyls (PCB)	-	-	29/04/2004	Annex I, part A Annex III, part A Annex IV
▲ ■	Polychlorinated naphthalenes	-	-	19/06/2012	Annex I, part A Annex III, part B Annex IV
▲	Tetrabromodiphenyl ether	-	-	24/08/2010	Annex I, part A Annex IV
○	Toxaphene	232-283-3	8001-35-2	29/04/2004	Annex I, part A Annex IV
■	Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF)	-	-	29/04/2004	Annex III, part A Annex IV
	Polycyclic aromatic hydrocarbons (PAHs)	-	-	29/04/2004	Annex III, part B

Table 1: List of persistent organic pollutants under the POPs Regulation in force in the European Union [6-7].

○: Pesticide; ▲: Industrial chemical; ■: Unintentional production; EC / List no: European Community Number / List number; CAS no: Chemical Abstract Service Registry number; Annex I to the regulation are subject to prohibition (with specific exemptions) on manufacturing, placing on the market and use; Annex II to the regulation are subject to restriction on manufacturing, placing on the market and use; Annex III to the regulation are subject to release reduction provisions; and Annex IV to the regulation are subject to waste management provisions.

Soil contaminants can be organized in several ways. Within the framework of this article, we describe a three-group division (organic, inorganic and radioactive).

1.1.1 Organic soil contaminants

Organic contaminants in soil are generally characterized by being highly persistent, easily accumulating, and many of them are TTMK (toxic, teratogenic, mutagenic, carcinogenic).

1.1.1.1 Organic solvents

These substances are highly flammable, explosive, toxic and persistent, so special rules apply to their storage and transport. May be released to the environment in the event of an accidental spill / leak, industrial and waste water, air emissions, and waste disposal. Prolonged exposure to solvent vapors can damage the respiratory system, cause tissue hypoxia and anemia, and affect thyroid function [9]. To date, much research is underway to develop alternatives to organic solvents, these are called green solvents [10-11].

1.1.1.2 Hydrocarbons

Hydrocarbons include a wide variety of compounds, from methane (CH4) with a very simple structure to aromatic hydrocarbons. In nature, we find large amounts of these compounds in crude oil and natural gas, which are processed and converted by petrochemistry. Polycyclic aromatic hydrocarbons (PAHs) are released into the environment from the combustion of fossil fuels and oil and coal sludge [12]. PAHs are a group of toxic aromatic xenobiotics with a benzene ring [13]. These compounds are highly hydrophobic and have a stable chemical structure, so they are poorly soluble in water and well soluble in lipids and therefore easily accumulate [14]. For this reason, they occur primarily in sediments and soils. Most PAHs have been shown to be carcinogenic, teratogenic and mutagenic in living organisms. The extent of adsorption of PAHs in soil is largely determined by the soil-specific organic carbon content [15-16].

1.1.1.3 Pesticides

Pesticides, also known as plant protection products, are used in agriculture. Commonly used types of insecticides are insecticides (insecticides), fungicides (fungicides) for protection against pathogens, and herbicides (herbicides) for plant pests. In addition, pesticides are produced for a wide range of uses, such as molluscicides, viricides, defoliants, etc. These substances have been used in large quantities until many of them have been shown to be highly carcinogenic, mutagenic, but also damage the reproductive and endocrine systems, and some agents cause developmental disorders and nervous system problems. One of the best-known such substances is DDT, which is now banned in most countries of the world (in Hungary in 1967) [17-18].

1.1.1.4 Fertilizers

Fertilizer use is an integral part of modern agricultural production. In order to ensure the increased demand for food, it has become necessary to replace the missing nutrients in the soil. However, inappropriate and long-term fertilizer use upset the nitrogen and phosphorus household of the soil, mobile nutrients leaching can cause eutrophication in surface waters. Nitrogene is introduced into the soil to form ammonia, which in turn is converted to nitrite and nitrate. These two compounds are already well soluble in water and, by infiltrating deeper water bodies with the infiltrating water, contaminate the drinking water supply. Nitrate pollution of water is particularly dangerous for infants because its consumption causes methaemoglobinaemia. Another problem is that the use of fertilizers introduces heavy metals into the soil and lowers the pH of the soil, which in turn increases the availability of newly introduced and normally present potentially toxic elements in the soil. Potentially toxic elements in large quantities adversely affect the physiological and biochemical processes of plants, damaging cells and cell organelles. Consumption of “metal-contaminated” plants is associated with biomagnification and damages the ecosystem [19-25].

1.1.2 Inorganic soil contaminants

Inorganic contaminants include potentially toxic elements and their salts, as well as radioactive elements. Members of all three groups are found in nature, but additional pollution that eventually enters the soil is possible from both natural (e.g., volcanic activity, forest fires) and anthropogenic (e.g., mining activity, municipal waste, tannery treatment effluents) sources [26].

1.1.2.1 Potentially toxic elements (PTES)

It is now a well-known fact that PTEs in high concentrations in soil pose a serious threat to human health and the ecosystem. The 8 most common PTEs in contaminated areas are Pb, Cr, As, Zn, Cd, Cu, Hg and Ni. Metal ions are not biodegradable, so they accumulate in tissues and biomagnify when they enter the food chain. This is especially true for Hg, Pb, Cd and As. Lead causes large amounts of, for example, urinary and nervous system damage [27-28].

Metals and inorganic salts are also necessary for the living organism, but in different amounts. In order for plants to grow and achieve good yields, it is important to keep soil mineral reserves at an adequate level. However, excessive salt and metal application has the opposite effect on plant development and results in a decrease in yield [29].

1.1.2.2 Radionuclides

About 80% of the radiation to which humans are exposed come from natural sources. The remaining 20% comes from radiation to the body due to medical examinations (18%) and from the activities of weapons experiments and the nuclear industry (2%). However, due to human activity, even at these proportions, humanity emits very significant radiation pollution into the environment. As a result of military exercises and energy production, the isotopes 137Cs and 97Sr have significantly and for a long time contaminated the soil in the affected regions. Radionuclides are also characterized by the ability of plants to absorb them, so that they enter the food chain and ultimately enter the human body. A good example of this is the two peaks of radiocesium activity measured in the UK, first detected in 1964 and then in 1986 in milk. The first date was the most active period for testing nuclear weapons, while in 86 the Chernobyl accident occurred (Department of the Environment, 1994) [30-33].

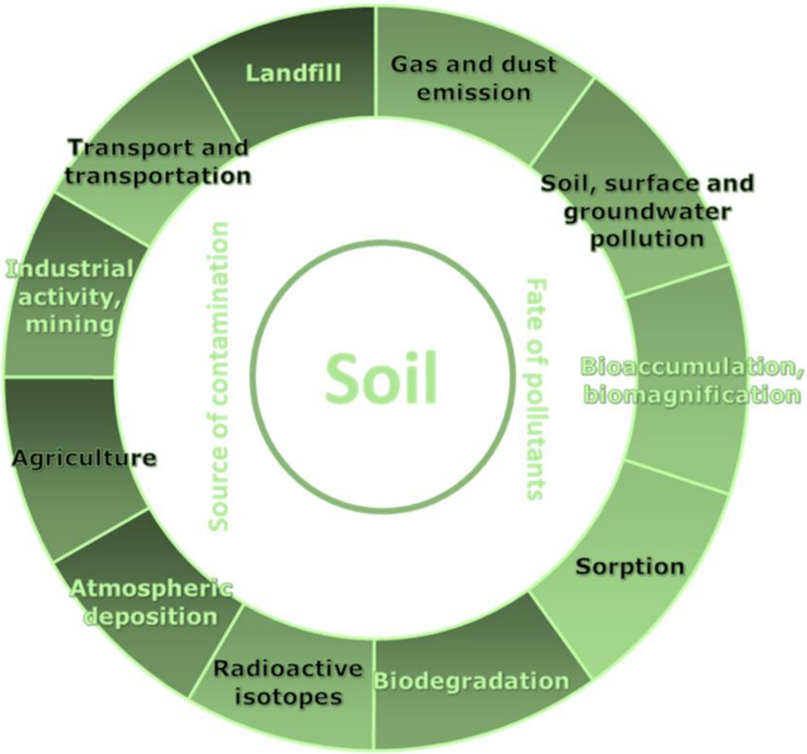

Figure 2. Tthe source of soil contamination and the fate of pollutant [4-33]

3. REGULATORY BACKGROUND

Due to their activities (transportation, manufacturing, warehousing) and the substances they use (raw materials, indirect materials, finished products), plants handling dangerous substances pose constant risk to the constructed and natural environment, and particularly to air, soil and the surrounding population. During the operation of the plants, such risks need to be analyzed on an ongoing basis, as environmental hazard may increase as a result of substance releases, equipment malfunctions or incorrectly performed maintenance activities. Environmental impacts of hazardous facilities can be effectively reduced by using the various elements of the Safety Management System.

In Hungary, Act CXXVIII of 2011 is deemed as the most important legal regulation in terms of disaster prevention. The legislation aims to regulate the execution of disaster management tasks, increase the safety and sense of safety of residents, and enhance the efficiency of defense against natural and technical disasters. The act seeks to achieve such aims by increasing the effectiveness of disaster management actions, as well as by restructuring and strengthening the disaster management organization. The legal regulation provides an accurate description on bodies that perform activities related to designing, organization, coordination, execution, management, establishment, operation, information, alarming, data communication and control, as well as on the required order of their cooperation. Regarding facilities handling dangerous substances, the act describes the fundamental specifications and requirements relevant to their establishment and operation. [34]

As per the definition provided by the Disaster Management Act, a plant handling dangerous substances shall be the whole of an area under the control of a specific operator, where dangerous substances are present in one or more facilities handling dangerous substances. Government decree 219/2011 (Oct 20) for the implementation of the aforementioned act specifies the volumes of dangerous substances, the presence of which makes a specific facility qualify as dangerous, regardless of whether the plant’s activity is classified as industrial, agricultural or other. It is the annex to the Government Decree that determines whether a specific plant is subject to the Disaster Management Act, and therefore facilities that are dangerous in terms of disaster management can be classified into the following categories: upper and lower tier establishments, plants under the threshold value and facilities to be handled with high priority. [35]

In relation to dangerous facilities, the definition of dangerous substance needs to be specified. The definition of dangerous substances – in line with the European Union regulations – is provided by Act XXV of 200 on chemical safety. Under such act, substances and mixtures are classified on the basis of their physico-chemical and chemical properties, explosiveness, toxicological qualities and characteristics, as well as their environmental impact i.e. ecotoxicological properties. [36]

Due to events generated during the manufacturing, storing and processing of dangerous substances, environmentally harmful materials may get released. Such releases may have adverse effect on air, surface and sub-surface waters, flora and fauna, residents, and may harm the Earth's surface and the soil. Explosions and fires pose hazard to the immediate surroundings of the affected facility; however, harmful substances that – as a consequence – get released to air or soil may pose extreme risk within tens of kilometers of range. [37]

In addition to the Disaster Management Act, in Hungary, the Act on environmental protection is also aimed to regulate the protection of environmental elements, and that of the Earth's surface, subsurface strata and soil in particular. When handling or using dangerous substances, as well as when applying dangerous technologies, protective measures need to be taken that mitigate or exclude the risk of environmental impact. While operating dangerous technologies, defense plans need to be prepared prior to performing the specific activity, in order to prevent any extraordinary environmental damage. [38]

Act CXXVIII of 2011 provides that in Hungary, the issuance of building permit for plants and facilities handling dangerous substances is subject to a license issued by the official disaster management authority, and furthermore, the performance of any dangerous activity is subject to disaster management license provided by the relevant authority. Establishment and operating permit may be provided on condition that the relevant safety documentation is submitted to and accepted by the Disaster Management Authority. From among the several obligations of the operator, compilation of safety documentation is one of their major responsibilities. Such safety documentation shall include the operator's requirements pertaining to the prevention and control of severe accidents involving dangerous substances, as well as specify the major objectives, principles and direction of development related to accident prevention. It is required to provide a summary on the operator's organizational structure, the method of identification and assessment of accident hazards, and the specific elements of defense planning; such actions aim to ensure that the operator provides high degree of protection in terms of health and environment. The level of risk posed by a dangerous activity shall be specified on the basis of the safety documentation by way of analyzing the hazard indicators identified.

In order to provide compliance with the requirements set out in the relevant legal regulation, operators have (safety) management systems in place. Such systems aim to implement the operator's safety policy that is targeted to prevent severe accidents and mitigate risks. In the case of dangerous facilities, the operation of such management system is a legal requirement, in terms of which, the aforementioned Government Decree 2019/2011 (Oct 20) provides detailed specifications. The primary aim of the system is to officially regulate the company's activities, develop and maintain safety of operations, as well as to continuously improve safety-related performance while promoting a positive safety culture. The system shall cover the organizational structure related to accident prevention and defense, the scope of responsibilities, procedures, and all resources required for the effective implementation thereof. As a minimum requirement, the organizational and personnel structure, as well as the relevant responsibilities need to be specified in connection with the prevention and control of accidents involving dangerous substances, and furthermore, hazards that may lead to severe accidents need to be identified, and the impact of such events shall be assessed. (Safety) Management Systems focus on the system of operating processes – and specifically review processes that have an effect on safe operation –, change management, safety performance assessment of the organization, as well as on the method and frequency of the related internal and external audits and the follow-up of the relevant findings. Benefits of an effectively operated (safety) management system include operation of increased efficiency and safety, decrease in the number of unexpected downtime events and malfunctions, more favorable insurance fees, better relations with the public, authorities, clients and press. [39]

Figure 3. The relationship between operational safety regulators and the safety management system [by authors]

1.2 Key elements of the safety management system

It is imperative that plants and facilities handling dangerous substances have all the information on the properties of technologies, equipment and materials they use, as well as on their impact on humans and the environment. In order for the safe operation of technological units, it is essential that such facilities have proper documentation which provides substantial information to maintain normal operation or control any potential emergency. Such documents primarily include the safety data sheets of dangerous substances, plan documentations containing the detailed and accurate description of technological processes, and technological instructions. [40] Based on the information available in relation to technological processes, operators shall determine the basic criteria for the safe and efficient operation of the specific technological systems.

Changes may occur from time to time in the technological systems due to various reasons. In order to guarantee safe operation, changes need to be managed according to the potential risks posed by such changes. Changes affecting the safety of technological processes include for instance the use of new or different materials in the specific technological system, as well as the use or storage of raw materials or indirect materials of changed composition within the facility. The key outcome of the change management process shall be a revised and approved application/proposal for change, which identifies and ensures risk management measures proportionate to the proposed change. By managing the identified risks, negative effects on the population or environment can be mitigated and reduced to an acceptable level. [41]

From the aspect of (safety) management systems, quality assurance procedures aim to provide that specific technological units, machines, equipment that are critical in terms of process safety are – in technical respect – in compliance with the technical and engineering best practices, as well as with the relevant legal requirements. The condition of specific devices, machines, equipment that constitute technological systems shall be continuously monitored during their entire lifetime; reliability is of particular importance in the case of technological units containing dangerous substances. In order to achieve such goals, the operator shall – in line with the principles of quality assurance – develop procedures to identify the methods of maintenance and operation of the specific devices, as well as to ensure the scheduling of the required controls and inspections.

One of the most efficient ways of knowledge sharing and learning is the investigation of incidents that have already occurred. In addition to actual incidents, one should also take into consideration the so called quasi-accidents or near misses – accidents that could have happened, but fortunately did not due to some reason (e.g. hazard was detected in due time). Investigation of root causes, however, is of equal importance in such cases as well, as it provides valuable information on non-compliant – or potentially hazardous – circumstances. Once the interrelations are identified, preventive and corrective actions need to be determined. It is important to specify well-defined tasks that can be assigned to specific owners with clear deadlines for execution. Implementation of the specified actions is crucial, and therefore, such shall be continuously followed up by the experts investigating the specific incident.

As for the preparation for and response to incidents, these days, it is an obvious obligation of operators to draw up emergency response plan to prevent the previously assessed emergencies, provide prompt intervention and reduce any further consequences arising therefrom. Efficient emergency response planning and prompt response can reduce the consequences of any event to a significant extent. In order to provide successful preparation for emergencies, one needs to focus on three key aspects: protection of human life, ability to efficient response, and effective communication with the parties concerned.

In dangerous plants, the functioning of (safety) management systems needs to be monitored in order to provide safe and reliable operation. Compliance can be verified by way of audits of various kinds, such as internal self-assessment audits or cross-functional audits. Internal inspections may be conducted by people – as assigned by the operator – who have in-depth understanding of the specific process safety management system, the technological process and the system under review. In addition to the so called self-assessment audit performed on one's own technological unit, it is also reasonable to conduct cross-functional audits where the inspectors include such auditors, too, who work outside the specific operational field, and therefore, the audit is conducted by experts who are responsible for different plants. The inspection may also be conducted by a third-party group of experts; in such case, however, it is reasonable to use a service provider that has extensive experience in the field of industrial process safety, and whose observations and recommendations can contribute to the even safer operation of the facility. Operators of dangerous industrial facilities shall have internal monitoring systems in place which help keep track of the status of safety-related objectives to be achieved. Such may be active monitoring systems, on the one hand, which are intended to achieve safety objectives targeted at incident prevention, and implement risk management actions, or reactive monitoring, on the other hand, which focuses on the reporting and investigation of failures and incidents that have already occurred. Inspections, in any case, aim to establish whether or not the operation of the management system meets the targets set by the operator. It is also important to examine to what extent the specified safety requirements and objectives are aligned. [42]

4. CONCLUSIONS

The authors wanted to depict the complexity of the topic in this complex article. The model experiments are practical laboratory activities with which it is possible to research the nature of soil pollution. Theoretical research, namely literary research, supports the methods and tools to be selected with the help of an international perspective. The effectiveness of legal regulations for preserving and maintaining the state of the environment is indisputable.

Highlighting the possible causes of industrial damage events are listed below. According to the experience of the last decades, the following facts have contributed to industrial accidents [40-42]:

- incomplete understanding of the system used;
- operators and / or supervisors had inappropriate qualifications or experience;
- the plant area for poor quality damage remediation;
- the work permit was inadequate and the lack of control over the repairs carried out;
- poorly performed emergency assessment, inaccurate individual and social risk;
- lack of consistent inspection of the work area immediately before restarting the plant;
- the employee was not properly informed about the task to be performed;
- there was no targeted inspection for the presence and use of personal protective equipment before work;
- incomplete or insufficient labeling of chemical containers;
- emergancy plans are not available
- inadequate communication between those involved in the work;

Finally, with the figure below, the authors tried to present the complex problem of soil pollution. Emphasizing the principle of restoring the environment to its original state. The figure was made by the authors based on their own professional experience.

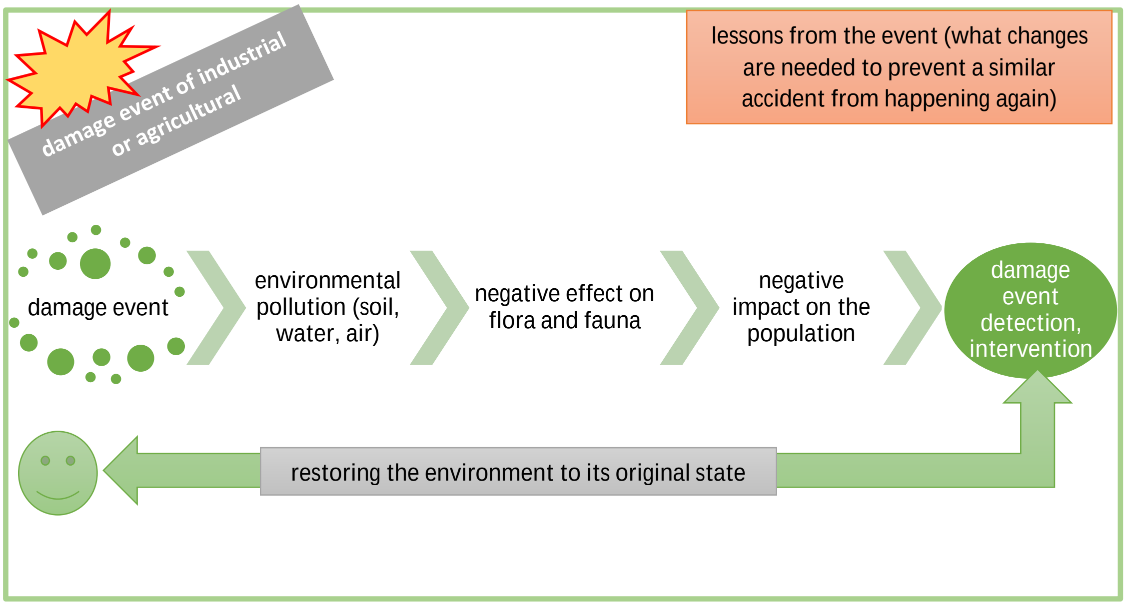

Figure 4. General presentation of the process involving the pollution of environmental elements [by the authors]

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