The Geological Surveys of Europe

EuroGeoSurveys feedback on the proposed regulation for a Directive on Soil Monitoring and Resilience

Introduction

Pressure on soil and land is increasing globally. The European Court of Auditors recently indicated that two-thirds of soils in the EU are currently under the threat of deterioration due to insufficient or missing soil management (SR-2023-19).

Healthy soil is the basis for food production, a crucial part of the natural resources exploitation (e.g., forest, groundwater), and acts as a driver of the resilience to climate change (including drought, floods and extreme weather events and even carbon dioxide capture). With an ever-growing world population, efficient food production is becoming a major challenge. Plant and animal production requires sufficient amounts of major and minor nutrients and low concentrations (or availability) of toxic elements in the soil.

Within the zero-pollution ambitions of the European Commission, a healthy planet for air, water and soil is expected for 2050. Pollution is aimed to be reduced to levels no longer considered harmful to health and natural ecosystems by re-creating as much as possible a toxic-free environment. This is a very ambitious target, which may not be fully achievable, and requires swift action to be taken across Europe to improve our living conditions in the short and long term.

EuroGeoSurveys (EGS) is a not-for-profit association, established in 1971, providing vital subsurface knowledge to support the EU's competitiveness, social well-being, environmental management and international commitments. EuroGeoSurveys coordinates a network of 37 National Geological Surveys of Europe, a workforce of more than 10,000, collaborating through 10 scientific expert groups and 1 international cooperation task force. We address European issues in the field of geoscience (science of the subsurface) and collaborate on projects that inform EU and national policy for the benefit of all European citizens. EuroGeoSurveys – and a future sustainable Geological Service for Europe – enables sustainable and responsible use of our subsurface space and its natural resources. As the scientific reference partner of the EU, we deliver near surface and subsurface knowledge as the foundation of a sustainable future for Europe.

EuroGeoSurveys welcomes the Proposal for a Directive of the European Parliament and of the Council on Soil Monitoring and Resilience (Soil Monitoring Law - SML) as a positive action toward improving the status of soils to support the EU's society and environment. Specifically, we note the significant roles that the National Geological Survey Organisations (NGSOs) collectively have already played during the preparation of the Soil Monitoring Law. That early engagement was solidified in continuous activities of one of EGS's dedicated expert groups, the Geochemistry Expert Group, and project-based focus on the pan-European geochemical mapping of (a) residual soil (Salminen et al., 2005; De Vos, Tarvainen et al., 2006), and (b) agricultural and grazing land soil (Reimann et al., 2014a, b).

Recommendations regarding the implementation of the Directive on Soil Monitoring and Resilience (Soil Monitoring Law)

- ✓ As an established partner, the EGS Geochemistry Expert Group (GEG), having managed two major soil surveys at EU scale (FOREGS 1997-2006 and GEMAS 2008-2014), and the National Geological Survey Organisations (NGSOs), supported by EGS, should be an active partner in the soil monitoring network.
- ✓ Some National Geological Survey Organisations (NGSOs) are the key national authorities which have the required national soil and subsurface data and knowledge to inform on Europe's soils status. Thus, those NGSOs with this mandate should play a role in the implementation of the Directive.
- ✓ The European Geological Data Infrastructure (EGDI), supported by the NGSOs, should be a platform of choice for delivery of soil data (and other related subsurface data). A close relationship between EGDI (and a future Geological Service for Europe) and EUSO and its future hub should be established.
- ✓ The expected times are long given that the obligation to adopt sustainable soil management measures comes into force four years after the entry into force of the Directive itself, so action should be taken in the meanwhile following yet established targets under the Soil Strategy.
- ✓ Future soil monitoring at the European scale has to be implemented taking into account the integrity of national interest. Notwithstanding the support to a fast implementation of the monitoring system, and to a reporting period of 5 years, it should be considered that the time interval for resampling has to be specific in relation to measured parameters, avoiding in certain cases repetition if known as useless, e.g., mean residence time of certain metals in soil is of few to several hundred years and re-analysing these parameters in samples from the same site every 5 years is therefore not necessary as it will add no new information.
- ✓ Ideally, soil sampling has to follow the principles of soil type, climatic conditions and land-use, as stated in paragraph 31 on p.24 of the SML. However, as this is rather difficult to achieve, a cost-effective random soil sampling plan across Europe should be designed at an appropriate sample density.
- ✓ In addition to a sampling and measuring approach, proxy indicators of soil health should be addressed, e.g. fleet mean axle load of agricultural machinery. This gives a better impression of possible negative future effects on soil health than post-hoc monitoring alone.
- ✓ The sampling design approach used in the GEMAS project guarantees a uniform sample coverage for any of the sampled land use types across Europe.
- ✓ It would be useful to insert another annex that considers methods, tools, criteria and good practices to promote soil regeneration, in line with the commitments of Agenda 2030, SDG 15.3.
- ✓ With reference to the topic of contamination, the Directive is a point of reference for Member States that do not have specific legislation on contaminated sites and a catalyst

for innovation for those who already have consolidated policies in this sector. This process can support the review and update of soil policies over time. An adequate degree of flexibility in the text is needed in order to take into account the policies implemented at a national level.

Issues to be addressed in the Soil Monitoring Law

- The proposed 2023 edition of the Soil Monitoring Law provides a very ambitious plan for the improvement of soil and its protection. However, in its recommendations the division of various duties and responsibilities (operational and financial) between the European Commission bodies and Member States is not always clear.
- The proposed Soil Monitoring Law has a main focus on agricultural soil and soil used for building infrastructure in the urban environment. Other types of soil use are given little attention, e.g., forest soil in relation to forest industry and soil occurring at various climate zones and elevations in its natural state. This significantly limits the possibilities of analysis independent of land use.
- It is stated that about 60 to 70% of soil in the EU is currently in an unhealthy state and all Member States are facing the problem of soil degradation. However, this statement is controversial and not valid for all countries and soil types. For example, in Sweden (untitled, jordbruksverket.se), about half of the area is covered by forest (forest soil), with another one third of mountains, marshes, and lakes. Cultivated area (i.e., agricultural soil, grazing land soil, to some degree urban soil) is only ca 7% of the total land area.
- According to the Directive, approximately 21% of agricultural soil in the EU contains cadmium concentrations in the topsoil that exceed the limit for groundwater. However, this statement is not followed by any source citation. The GEMAS results for Cd in agricultural soil do not verify such a picture (Birke et al, 2017, 10.1016/j.gexplo.2016.11.007). There are regions in Europe where Cd high concentrations are clearly of geogenic origin (i.e., naturally occurring) and there are even national strategies how to mitigate these problems in agriculture.
- With respect to the “no net land take” objective by 2050 even if the definition of specific reduction obligations is lacking, the annual monitoring could be a good basis for giving impetus to this central aspect. Land take definition is very clear and correct.
- Accordingly to the objective of no net land take in 2050 and synergies with other Directives, land-take monitoring systems should take into account other specific classes, i.e. the development of green technologies such as wind farms or solar panels, allowing the consideration of the related positive impacts on other environmental aspects. This can help processes for various industries like wind farms, mining, quarries, dams, pipe-networks, etc., which also work together towards a fossil-free society. During national discussions, this conflict is often mentioned. Better relationships to other Directives should be visible in the document.

- The soil in relation to exploitation of natural and mineral resources has little attention in the Directive. We recommend a broader approach in this topic as the EU Critical Raw Materials Act may facilitate new exploitation in EU.
- The definition of healthy soils as untouched by humans raises problems with management of natural soils with high levels of metals and other potentially toxic elements. Natural background in soil, mapped at continental scale, should be recommended as starting point for assessments of pollution, and possibly defined at national level.
- The soil status, chemical and physical, should be evaluated in relation to natural background as well as in relation to the land-use. The diversification between high natural metal contents in soil and soil pollution is not well described. This way, natural soils with high metal concentrations may be interpreted as polluted and subdued remediation actions or excluded from land-use exploitation plans, generating additional large and prohibitive costs for local communities.
- Threshold values for soil chemical composition must be related to the natural background concentrations at the regional to local scale and to land use categories. Therefore, they cannot be the same for all soil types and European landscapes-regions (Reimann et al., 2018; Gosar et al., 2019).
- Soil health is defined from the anthropocentric perspective and in relation to ecosystem services. However, these services are difficult to measure.
- The proposition of ‘soil districts’ is controversial and may not be possible or very difficult to use at the European scale in a standardized way. After discussions at the national level, we suggest to leave the appropriate flexibility in the definition within each country.
- Among many EU initiatives, which are mentioned in the document, there is little attention to the interplay between Soil Directive and recently published Critical Raw Materials Act and to industry related directives targeting green transition, regional development etc. We propose to include such interface connection.
- The Directive does not provide sufficient / adequate methodologies or criteria for measuring ‘soil health’ in land-use types other than agricultural soil. This gap should be filled. It may be that the parameters proposed in the Annexes are not suitable for all land-use types. As discussed by several Member States, we propose to consider – at least for some parameters – a set of threshold values at macro region or climatic region level, to take into account the macro differences between European territories.
- The monitoring concept presented in Articles 1, 6, 7, 8 and 9 does not clearly explain who is the main actor responsible financially and operationally for soil monitoring (e.g., Member States or the LUCAS programme - JRC). The role of LUCAS in carrying out soil sampling, analytical work and data management is not clearly explained. Quality assurance and control of sampling and analysis should be addressed more precisely (a source of error can result from the execution of sample collection and soil field assessments by personnel who are not qualified for such tasks). Studies (e.g., BZE II in Germany) demonstrate that the greater variation in measurement values is not caused by the laboratory but by the sampling procedure. Thus, experienced and qualified personnel that are specifically trained using already existing guidelines should conduct sampling. On page 10 and 16 of the document, the responsibility for monitoring is put on Member States (“*Article 9 requires*

Member States to assess soil health based on regular soil measurements in order to ascertain whether the soils are healthy"), while in paragraph 32 the Commission offers the assistance of LUCAS programme in monitoring ("*The Commission should assist and support Member States' monitoring of soil health by continuing to carry out and enhancing regular in-situ soil sampling and related soil measurements (LUCAS soil) as part of the Land Use/Cover Area frame statistical Survey (LUCAS) Programme*"). This may imply that Member States need to finance the monitoring which is being carried out by an external (not national) body, without the means to access the results in the short term, as proved in the last three LUCAS campaigns. The procedure for carrying out monitoring should be explained in more understandable way. The Member States must clearly know what their responsibility is, especially given that some countries already have soil monitoring programmes and they do not want to do or pay for double work.

- Is it foreseen that LUCAS will provide some expertise and services or only the digital platform for data storage and sharing? It is not specified how Members States can have the first right and unlimited access to their national data collected in this centralized manner. The monitoring suggests resampling every 5 years, which seems expensive and simply not needed at the continental scale since most of the parameters do not change in such short timeframes. For example, for metals, the mean residence time of lead in the O-horizon of a mature forest is about 250 years and in the older parts of the chronosequence it was at least >170 years (Klaminder et al., 2006). This time interval of 5 years makes monitoring, which is resampling of ca. 20 000 soil samples (according to the last three LUCAS surveys), seem far too expensive for Member States and potentially in conflict or competition with national programmes if such exist. We recommend a time interval of minimum 15 to 20 years, with the exception of some specifically known polluted areas, which may have a tighter sampling schedule.
- It should be clearly defined how many parameters have to be re-run in regular time intervals. There are monitoring parameters defined in Annex I, and Group A parameters have criteria for healthy soil established at EU level: Salinization, Soil erosion, Loss of soil organic carbon (organic soils / mineral soils), subsoil compaction. Soil salinization is not an important soil threat in many countries, especially in northern Europe (e.g., Finland, Sweden). This raises the question as to whether these parameters should apply equally in all Member States, or only at more regular intervals where needed and less where they do not bring any new value. Subsoil compaction is another parameter that could be seen as a problem in agricultural soils with heavy machinery on certain soil types and in forests where harvesting can cause compaction of subsoil or topsoil. In urban areas, compact soil is actually the desired type for building and heavy constructions. EuroGeoSurveys in co-operation with other research institutes could help to provide mapping data on soils and subsoils that can help to delineate areas for the densest monitoring of certain soil threats. For this issue and to elaborate adequate sampling designs, physical based measurement methods such as hyperspectral imaging and gamma spectrometry on the ground, airborne using drones, and, in the case of hyperspectral measurements, even from satellites, could be used in addition to time- and cost-intensive soil sampling and analysis. The technique provides cost-effectively valuable temporally high-resolution spatial information about surface soil conditions, soil degradation, and land use change.

- There are many contradictory statements in the proposed Soil Monitoring Law, e.g., on p.4: "*There is currently a lack of comprehensive and harmonized data on soil health from soil monitoring. Some Member States have soil monitoring schemes in place, but they are fragmented, not representative and not harmonised. Member States apply different sampling methods, frequencies and densities, and use different metrics and analytical methods, resulting in a lack of consistency and comparability across the EU*". In the following paragraph it proposes "*a solid and coherent soil monitoring framework for all soils across the EU, which will address the current gap of knowledge on soils*". According to disadvantages of statistical sampling designs as used in the LUCAS project, e.g. high effort for an appropriate spatial sampling density, stratified soil monitoring approaches should be taken into account to allow adequate estimation of trends on soil parameters in an affordable way. In addition, for characterizing carbon storage in soils or soil compaction, it is not sufficient to sample only from 0-20 cm. To assess carbon storage in soils, e.g. density measurement in peat soils is also necessary in addition to determination of thickness. Consequently, an elaborated and uniform sampling and sample preparation scheme (storage time of soil samples should be adapted to target parameters), where, for example, bulk density is determined at a single profile in different depths, should be designed and consequently implemented. However, the following sentence "*It should be an integrated monitoring system based on EU level, Member State and private data*" indicates the intention of data compilation and therefore the production of non-harmonised data.
- The following statement at the bottom of page 4 says: "*This technological progress is expected to give farmers and foresters easier access to soil data, and also lead to a wider range, better availability and more affordable technical support for sustainable soil management, including decision support tools*". However, so far, after nearly 15 years, the three sampling campaigns of the LUCAS project have not made available all the analytical data, including the "heavy metals", i.e., the potentially toxic elements, which are of interest to the farmers and foresters. In addition, the LUCAS project does not provide uniform sample coverage across Europe for any of the sampled land use types. This results in significant sampling gaps not only across Europe but further exacerbates the issue for each of the five sampled land use categories, despite the planned and previous sampling efforts. The new Soil Directive should include a legal statement of when and how the collected national data are available for Member States.
Sampling density of any soil monitoring programme is unlikely to be appropriate to serve data needs of individual farmers and foresters.
- The definition of 'contaminated site' and 'potentially contaminated site' in the Directive is not clear and may cause many legal and practical problems. An investigation of national definitions of contaminated sites should be precursory to introduction of EU-level requirements.
- Many Member States have very well-developed programmes, routines and legal systems for management of polluted areas (including soil). In the Directive it is not clear how these can fit in the centralized EU model. This may become a potential source of conflict or create additional unnecessary administration which can be costly. The EC role in the evaluation of polluted soil sites may interfere with national programmes and national

integrity of their legal systems and policies. Broader consultation with Member States should be performed to harmonize practices.

Comments on the ANNEXES 1 to 7 of the Soil Monitoring Law

- Page 1: European Soil Data Centre (ESDAC) in “Erosion in Europe - Projections by 2050” with Revised Universal Soil Loss Equation (RUSLE), currently estimates that the mean soil erosion rate in the EU and UK, is around 3.07 t ha-1 yr-1 (2016).
- Among all Member States, Italy is the country most affected by soil erosion with more than 8.7 t/ha/year, a value well above the EU average (Panagos *et al.*, 2015). Within the proposal (Annex 1) the criteria for establishing a healthy soil condition is a rate ≤ 2 t/ha/y, so the current framework at European level is that almost all are considered unhealthy soils. In our opinion this limit is too restrictive, so other threshold should be taken into account (e.g. the estimate of tolerable erosion rate equal to 11.2 t/ha/year proposed by the Soil Conservation Service - USDA).
- The value of 2 t/ha/y strongly depends on equations used to calculate the erosion factors (R, LS, C and K) according to the RUSLE methodology: this approach deeply changes the order of magnitude in the final assessment. The most important parameters influencing the assessment are R and LS factors, so Member States should establish its thresholds depending on local characteristics of each Soil District (topography, microclimate, soil condition, land use/land cover).
- Pages 3 & 8: the term “heavy metals” must not be used because As and Sb are non-metals. It should be replaced by “potentially toxic elements”.
- A decision to use dilute nitric acid (ISO 17586:2016) as analytical method for the determination of potentially toxic elements (i.e., As, Sb, Cd, Co, Cr (total), Cr (VI), Cu, Hg, Pb, Ni, Tl, V, Zn (µg per kg)) in the collected soil samples is controversial. Tests in some countries (e.g., Lithuania) show that nitric acid leach leaves out up to 80% of results for some metals below detection limit. For example, it is difficult to determine Sb content in soil using nitric acid dilution, the preferable method is aqua regia digestion. Member States use both methods and a broader survey should be made to investigate the best choice of method for metal determination.
- Concerning soil organic matter (SOM), it is not yet decided whether the limit values will be EU-wide or whether each country will set their own. The latter is preferable, because the SOM in Mediterranean countries is quite different from Nordic countries (humus-rich soil and peat), mainly due to climatic conditions.
- Monitoring of some soil parameters (salinization, erosion, compaction) should be flexible, and adapted to national conditions. For example, according to LUCAS data, there is no soil erosion in Lithuania, however according to the National Atlas, ca 20% of soils used for agriculture are affected by erosion. Of these, 61% are moderately eroded (up to B horizon) and 2% severely (up to C horizon) eroded (Dirvožemio apsauga - Problemos (dirvozemioapsauga.lt)).

- Members states see a lot of uncertainties and contradictions in the Soil Health Law draft concerning descriptors, indicators, between potentially contaminated and contaminated soil. Almost all the definitions have their "national meaning" in different countries, and all the countries are suspicions concerning of implementation of SHL. Better vocabulary and term definitions are needed.
- All potential impacts coming from the construction sector and new housebuilding should be carefully taken into account; it is necessary to link the measures considered in this proposal with the existing Environmental Impact Assessment Directive (Directive 2011/92/E).
- Between the optional indicators, the loss of ecosystem services produced by land take should be better quantified using a standard methodology common to and shared by all Member States.

Possible roles of the National Geological Surveys and EGS in the implementation of the Soil Monitoring Law

1. As a source of data and expertise

Data on the subsurface, as is the case for soil evaluation, requires specific expertise to be used, displayed, and interpreted. In many cases, the source of soil data and the expertise on the geological-derived nature and human impacts and its suitability for defining the soil status is held by the NGSOs, either through national programmes or research programmes shared by NGSOs. EGS and its NGSO members established a Geochemistry Expert Group (GEG) in 1985, dedicated first to continental scale geochemical mapping. Since that date, the GEG has been engaged in continental-scale geochemical projects to fulfil a variety of purposes and uses regarding soil. The first major continental scale undertaking was the FOREGS Geochemical Atlas of Europe, carried out from 1997 to 2007, resulting in the publication of a two-volume atlas (Salminen et al., 2006; De Vos, Tarvainen et al., 2007). This work contributed to the Global Geochemical Baselines project of the International Union of Geological Sciences for the establishment of the European Global Geochemical Reference Network. It covered 26 countries and an area of 4.25 million km^2. A second project followed, GEMAS (GEochemical Mapping of Agricultural and grazing land Soil), carried out from 2008 to 2014, with the publication of another two-volume atlas (Reimann et al., 2014a, b). It covered 33 European countries and an area of 5.6 million km^2. The data (soil geochemical composition and other parameters) obtained from both projects are available to the public. Additionally, the GEMAS project has prepared the soil standard which can be used in other soil surveys, as recommended in the Soil Directive's Annex II, part B.

We therefore stress the important position of the NGSOs, their diverse expertise, practical experience and their close relation with local and national authorities in implementation of the soil protection laws and establishing good routines for soil monitoring.

2. As an expert network

The structuring project GEMAS - GEochemical Mapping of Agricultural and grazing land Soil - builds upon achievements from prior European assessments and the joint activities of our Geochemistry Expert Group (GEG), which currently comprises 66 members from 35 countries, the Earth Observation and Geohazards Expert Group (EOEG) and the Urban Geology Expert Group (UGEG), which develop the potential for bringing together data and expertise that reaches far beyond EGS members. Moreover, GEMAS produced the first pan-European geochemical mapping of agricultural soils atlas now displayed through the EGDI platform, an open access service provided by EGS and being further developed through the GSEU project ("A Geological Service for Europe" – Horizon Europe funded project). As the authoritative national research and public policy advisory bodies that deal with subsurface data, including but not limited to soil geochemistry, and with strong links to the wider soil research community, the NGSOs comprise a coordinated network that could act as a structural expert group to the proposed Soil Directive.

3. As a data infrastructure provider

The EuroGeoSurveys Geochemistry Expert Group provides high quality geochemical data of near-surface materials and develops harmonised geochemical databases for multi-purpose use: "one project – many customers". Such designed projects deal with the soil geochemistry, the geochemistry of European bottled water, as well as the chemical environment of urban areas. Each project delivered a detailed manual with sampling techniques, analytical protocols, and data management (Salminen, Tarvainen et al., 1998; EGS, 2008; Demetriades and Birke, 2015a, b). With these data sets, GEG offers independent unbiased expert advice to the European Commission, and supply of sound geochemical background/reference data to society through a central data hub within EGDI.

A special focus of GEG lies in the execution of pan-European applied geochemical projects using harmonised and quality-controlled procedures of sampling, sample preparation, and laboratory analysis to produce high-quality data for multipurpose use. The scope is to bring together applied geochemists with various specialties (e.g., environmental, mineral exploration, ground water geochemistry) from all EGS member institutions, and provide a forum for the exchange of expertise.

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APPENDIX 1: Chemical characteristics of contaminating activities

Here we present the table of contaminating activities and their probable organic and inorganic contaminants which was compiled according to the European Classification of Economic Activities, NACE (EuroStat, 2008). This table was first compiled for use in the European Commission co-financed project NORISC (Network Oriented Risk assessment by In-situ Screening of Contaminated sites, EVKT-CT-2000-0026), which was completed in 2004 (https://cordis.europa.eu/project/id/EVK4-CT-2000-00026) and finally updated in 2015, published by EuroGeoSurveys, with additions from Gihr *et al.* (1990) and Birke *et al.* (2009):

Activity: Industry, Enterprise	***Organic contaminants***	***Inorganic contaminants***
Agriculture (including chemical & livestock fertilisers)	Pesticides, Herbicides, Insecticides	As, B, Ba, Ca, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, P, Pb, Sb, Se, Zn, NH_3, nitrates, nitrites, sulphates, CN, Cl^-, F^-
Airport	BTEX, PCBs, TPH, VHH, MOHC, Phosphate ester	As, Br, Cd, Hg, Pb, SO_2, CO_2, CO, NO_x, N_2O, NH_3
Automobile repair and painting	BTEX, MTBE, PAHs, PCBs, TPH, VHH, aliphatic hydrocarbons, Chlorinated hydrocarbons, Organolead compounds, AOX, Phenol index	Cd, Cl^-, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se, Ti, Zn, Sulphate
Battery	PCBs, PAHs, Hydrocarbons	Be, Cd, Cu, Fe, Hg, K, Mg, Mn, Ni, Pb, Se, Zn, Sulphate
Beverages manufacture	BTEX, PAHs, PCBs	Cu, Cr, Pb, Zn, SO_x, Nitrates, Phosphates
Brick making industries	BTEX, TPH, PAHs, PCBs, Aliphatic hydrocarbons	Al, B, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn
Cartridges manufacture and Shooting ranges	PCBs, Nitroaromatics	Ba, Cl^-, Cu, Ni, P, Pb, Sn, Sr, Zn and inorganic compounds
Cast iron smelting	BTEX, PAHs, PCBs, TPH, Hydrocarbons, Phenol index	B, Cl^-, CN, Fe, Mn, P, Sulphate
Cement manufacture	BTEX, HFCs, TPH, PAHs, PCBs, Aliphatic hydrocarbons, Dioxins, Furans	Al, As, Be, Cd, Cl, Co, Cr, Cu, F, Fe, Hg, Mn, Ni, Pb, Sb, Tl, V, Zn, NH_3, NO_x, SO_x, Sulphate
Chemical fertilisers manufacture, including phosphate fertilisers	PAHs, TPH, Hydrocarbons, Pesticides	As, Cd, Cr, Cu, Hg, Mn, Ni, P, Pb, Sb, Se, V, Zn and inorganic compounds
Chromite smelting	BTEX, PAHs, PCBs, TPH	Cr, Ni, Fe, V
Copper smelting and production	BTEX, PAHs, PCBs, TPH, Hydrocarbons, AOX, Hexachlorbenzol	Al, Ag, As, Au, B, Ba, Cd, Co, Cr, Cu, F^-, Fe, Ni, P, Pb, Pd, Pt, Sb, Se, Sn, Te, U, V, Zn, Nitrate, Nitrite, Sulphate, Sulphide, Sulphite, CN

Activity: Industry, Enterprise	***Organic contaminants***	***Inorganic contaminants***
Cosmetics, Toiletries & Disinfectants manufacture	BTEX, PAHs, PAE, PCBs, VHH, Phenols, Chlorophenols, Dioxins, Furans, Chlorinated aromatic hydrocarbons	As, B, Ba, Cr, Cu, Hg, Ni, Pb, Zn
Dockyards (including shipbuilding)	BTEX, PAHs, PCBs, TPH, VHH, Biocides, Pesticides, Phenols, Chlorophenols, Aliphatic hydrocarbons, Organotin compounds	As, Cd, Cr, Cu, F^-, Fe, Hg, Mg, Mn, Ni, Pb, Sn, Zn and inorganic compounds (CN)
Electric power plant & distribution station	PAHs, PCBs, BTEX, Hydrocarbons	As, B, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, V, Zn, Sulphate
Farming of animals (including pig, cow, sheep, goat & poultry)	Pesticides, Phenol index, Hydrocarbons	As, B, Cd, Cr, Cu, Fe, Hg, Mn, Ni, P, Pb, Sb, Se, Zn, NH_3, nitrates, nitrites, sulphates, Cl^-
Food products and beverages manufacture (including all types of food manufacturing, *e.g.*, dairy products, canned fruit, juice & vegetable)	Acetaldehyde, Acetone, Ethylene glycol, Methanol, Pesticides, HFCs, CH_4, BTEX, PAHs, Pesticides, Volatile hydrocarbons	Ba, Cd, Cu, Hg, Ni, P, Zn, Ammonia, Ammonium sulphate (solution), Phosphoric acid, Sulphuric acid, Nitric acid, Chlorine, NH_3, NO_x, nitrates, nitrites
Footwear manufacture	PAHs, Toluene, Methyl ethyl ketone, Acetone, Glycol ethers, Xylene, Methyl isobutyl ketone	Al, As, B, Ca, Cd, Cr, F^-, Fe, Hg, Mg, Mn, Na, P, Ti, Sr, NH_3, Ammonium sulphate, Nitrate, Nitrite
Funeral and related activities (including Cemeteries)	Formaldehyde, various organic pollutants (Furans, Dioxins, Hydrocarbons, Phenols)	As, Cu, Fe, Hg, Pb, Zn, Phosphates, Ammonium, Nitrates
Furniture manufacture	BTEX, PAHs, Phenols, Phenol index, Total chlorophenols, Pesticides, Aliphatic hydrocarbons, Organotin compounds	As, B, Cu, Cr, F^-, Hg, Ni, Pb, Zn, NH_3
Glass manufacture	BTEX, HFCs, PAHs, TPH, VHH, Aliphatic hydrocarbons, Dioxins, Furans, Phenol index	Ag, As, B, Ba, Bi, Cd, Cl, Co, Cr, Cu, F^-, Fe, Hg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sn, Ti, Tl, Zn, Zr, NH_3, NO_x, SO_x, and inorganic compounds (Nitrate, Sulphate, Sulphide)
Hospital activities	BTEX, PCBs, TPH, PAHs, Phenol index, Phenols, Hydrocarbons, Organic acids, Pesticides	Ag, Al, As, B, Ba, Be, Bi, Cd, Cl^-, Co, Cr, Cu, Fe, F^-, Ge, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Sn, Ti, Pt, Zn, Zr, CN
Leather clothes manufacture	PAHs, Toluene, Methyl ethyl ketone, Acetone, Glycol ethers, Xylene, Methyl isobutyl ketone, Phenol index, Hydrocarbons	As, B, Ca, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, CN, Ammonium sulphate, Nitrates, Nitrites, NH_3

Activity: Industry, Enterprise	*Organic contaminants*	*Inorganic contaminants*
Machinery including electrical	BTEX, PAHs, PCBs, TPH, VHH, Phenols, Chlorophenols, Dioxins, Furans, Aliphatic hydrocarbons, 1,1,1-Trichloroethane, Freon 113, Trichloroethylene, Methyl ethyl ketone, Dichloromethane, Hydrocarbons	As, B, Cd, Cl^-, Cr, Cu, Fe, Hg, Ni, P, Pb, Sn, Zn and inorganic compounds (Sulphuric acid, Nitric acid, Nitrite, Ammonium sulphate, Sulphate)
Metal plating & aluminium anodising including galvanised pipes	NMVOC, PAHs, PFCs, SF_6, Cyanide, Benzene, 1,1,1-Trichloroethane, Dioxins, Furans, BTEX, Hydrocarbons, AOX, Organic acids	Al, As, B, Cd, Cl^-, Co, Cr, Cu, F, Fe, Hg, Mg, Mo, Ni, P, Pb, Sb, Sn, V, Zn, Sulphuric acid, Hydrochloric acid, NH_3, NO_x, SO_x, Sulphate, CN
Metal smelting, Metal treatment & Metal Works	BTEX, PAHs, PCBs, HCB, TPH, Phenols, Dioxins, Furans	Al, As, Ca, Cd, Cl^-, Cr, Cu, F^-, Fe, Hg, Mg, Mn, Mo, Ni, Pb, Sn, V, Zn, Zr, and inorganic compounds (HCN, CN, Sulphate)
Military installations, including explosives	BTEX, NMVOC, PAHs, PCBs, TPH, Hydrocarbons, Nitroaromatics	As, Ba, B, Ca, Cd, Cl^-, Cr, Cu, Hg, K, Mg, Na, Ni, P, Pb, Sn, Sr, Zn, NH_3, NO_x, Asbestos, Nitrate, Nitrite, Sulphate
Mining of non-ferrous metal ores, except uranium and thorium ores	BTEX, PAHs, PCBs, TPH	As, B, Cd, Cr, Cu, Hg, Ni, Zn, Cl^-, sulphates
Mining: Asbestos	BTEX, PAHs, PCBs, TPH	Co, Cr, Ni, asbestos fibres
Mining: Chromite	BTEX, PAHs, PCBs, TPH	As, Cr, Ni, Fe, V, Zn
Mining: Copper	BTEX, PAHs, PCBs, TPH	As, Ba, Cd, Co, Cr, Cu, Fe, Ni, Pb, U, V, Zn
Mining: Pyrite	BTEX, PAHs, PCBs, TPH	As, Ba, Cd, Co, Cr, Cu, Fe, Ni, Pb, U, V, Zn
Non-metallic industries (including brick makers, stone makers & plaster)	BTEX, TPH, PAHs, PCBs, Aliphatic hydrocarbons	Al, B, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn
Paint and lacquer manufacture	BTEX, PAHs, PCBs, VHH, Phenols, Organotin compounds	Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Ti, Zn, Sulphide
Pesticides/ herbicides/ Insecticides manufacture	BTEX, PAHs, TPH, VHH, Chlorophenols, Dioxins, Furans, Aliphatic hydrocarbons, Organotin compounds	As, Ca, Cd, Co, Cr, Cu, F^-, Hg, K, Mg, Na, Ni, Pb, REE, Sb, U, Zn and inorganic compounds (sulphate)
Petrol station	BTEX, MTBE, TPH, Aliphatic hydrocarbons, Organolead compounds, Trichloroethylene, AOX	Ba, Cl^-, Cu, Cd, Fe, Mn, Pb, Ni, Zn, Sulphate

Activity: Industry, Enterprise	***Organic contaminants***	***Inorganic contaminants***
Petroleum bulk storage	BTEX, MTBE, NWVOC, PAHs, PCBs, TPH, Phenols, Aliphatic hydrocarbons, Organolead compounds, AOX	As, Cd, Cl^-, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, V, Zn, CN, NH_3, SO_x, Ammonium sulphate, Sulphate
Petroleum refinery & Bulk storage (Manufacture of coke, refined petroleum products and nuclear fuel)	BTEX, MTBE, NWVOC, PAHs, PCBs, TPH, Phenols, Aliphatic hydrocarbons, Organolead compounds, Pesticides (screening)	As, Cd, Cl, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sb, V, Zn, CN, NH_3, SO_x, Ammonium sulphate
Pharmaceuticals	BTEX, DCM, NMVOC, PAHs, PER, TCM, TRI, VHH, Chlorophenols, Phenol index, Aliphatic hydrocarbons, Chlorinated aromatic hydrocarbons, Organic acids	As, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Sn, V, Zn and inorganic compounds (NH_3, NO_x, SO_x), CN
Photographic processing	BTEX, VHH, Phenol index, Aromatic amines, Organic acids	Ag, As, B, Br, Ca, Cd, Cr, Cu, Hg, K, Mg, Na, Pb, Sb, Zn and inorganic compounds (CN, Ammonium, Sulphate, Sulphite, Sulphide)
Plaster making industries	BTEX, TPH, PAHs, PCBs, Aliphatic hydrocarbons	Al, B, Cd, Cl^-, Cr, Cu, F^-, Fe, Hg, Mn, Ni, P, Pb, Ti, Zn
Plastic products	BTEX, PCBs, Acetone, Dichloromethane, Methyl ethyl ketone, Methanol, 1,1,1-Trichloroethane, Styrene, Phenols, Pesticides (screening), Hydrocarbons, Organic P, Phenol index, AOX, Tetrahydrofuran, Dimethylformamide	Al, B, Ba, Ca, Cd, Cr, Cu, Fe, Hg, Pb, Sb, Sn, Sr, Ti, Zn, CN, Carbon disulphide, Nitrite, Sulphate, Sulphite, Sulphide
Pottery/Ceramics	BTEX, HFCs, PAHs, PCBs, TPH, Aliphatic hydrocarbons, Dioxins, Furans	As, B, Be, Cd, Cl, Co, Cr, Cu, F, Hg, Ni, Pb, Se, Sn, Ti, Tl, Zn, Zr, NH_3, NO_x, SO_x, and inorganic compounds
Prepared feeds manufacture for farm animals	BTEX, PAHs, VHH, Pesticides, Phenols	As, Cd, Cr, P
Prepared pet foods manufacture	BTEX, PAHs, VHH, Pesticides, Phenols	As, Cd, Cr, P
Processing and preserving of meat and meat products	BTEX, HFCs, PAHs, VHH, Pesticides, Phenols	As, Cd, Cr, NH_3, NO_x
Publishing, printing and reproduction of recorded media	BTEX, PAHs, PCBs, VHH, Phenols, Organotin compounds	B, Ba, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Sb, Se, Ti, Zn

Activity: Industry, Enterprise	***Organic contaminants***	***Inorganic contaminants***
Pulp, paper and paperboard manufacture	PAHs, PCBs, NMVOC, TPH, VHH, Pesticides, Phenols, Chlorophenols, Dioxins, Furans, Aliphatic hydrocarbons, Phenol index, Derivatives chlorinated benzene	Al, As, Ba, Cd, Cr, Cu, Hg, Mn, Na, Ni, P, Pb, Sb, Ti, Zn, Hydrochloric acid, Sulphuric acid, NO_x, SO_x, Ammonium sulphate, Chlorine, Chlorine dioxide
Rubber products	BTEX, PAHs, TPH, VHH, Phenols, Chlorophenols, Aliphatic hydrocarbons, Chlorinated aromatic hydrocarbons, Phenol index	Al, As, Ba, Ca, Cd, Cl^-, Cr, Cu, Fe, K, Mn, Mg, Na, Ni, Pb, S, Sb, Se, Te, Ti, Zn, and inorganic compounds (Thiocarbonate, Sulphuric acid, Hydrochloric acid, Sulphate, Sulphide)
Sawmilling and planing of wood; impregnation of wood	BTEX, PAHs, PCBs, Phenols, Total chlorophenols, Phenols, Pesticides, Aliphatic hydrocarbons, Organotin compounds, Nitroaromatics	As, B, Ba, Ca, Cl^-, Cu, Cr, F^-, Hg, Mg, Na, Ni, P, Pb, Zn, NH_3, Nitrate, Nitrite, Sulphate
Sewage and refuse disposal, sanitation and similar activities (including household wastes)	BTEX, MTBE, PAHs, PCBs, HFCs, PFCs, TCE, TCM, TPH, VHH, Pesticides, Phenols, Chlorophenols, Dioxins, Furans, Aliphatic hydrocarbons, CH_4, Chlorinated aromatic hydrocarbons, Organolead and Organotin compounds	As, B, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Zn and inorganic compounds (NO_x, SO_x, Hydrochloride, *etc.*)
Shipbuilding	BTEX, PAHs, PCBs, TPH, VHH, Biocides, Pesticides, Phenols, Chlorophenols, Aliphatic hydrocarbons, Organotin compounds	As, Cd, Cr, Cu, F^-, Fe, Hg, Mg, Mn, Ni, Pb, Sn, Zn and inorganic compounds (CN, Sulphate)
Slaughterhouses	BTEX, HFCs, PAHs, VHH, Pesticides, Phenols	As, Cd, Cr, NH_3, NO_x
Stone making industries	BTEX, TPH, PAHs, PCBs, Aliphatic hydrocarbons	B, Cd, Cr, Cu, Hg, Ni, Pb, Zn
Tanning and dressing of leather	BTEX, MTBE, VHH, Aliphatic hydrocarbons, phenols	Cr^{3+}, Cr^{6+}, Cd, Pb and inorganic compounds (NO_x, Hydrochloric acid, Chlorides, Sulphides)
Textile finishing (*e.g.*, Textile bleaching & dyeing)	BTEX, NMVOC, PAHs, TPH, PCPs, Pesticides, Phenols, Chlorophenols, Hydrocarbons	Al, B, Ba, Cd, Cr, Cu, Hg, P, Sn, Ti, Zn, Sulphates, Sulphuric acid, Caustic soda, Sodium hypochlorite, Ammonium sulphate, Ammonia, Phosphoric acid, NO_x, SO_x, Cl^-, F^-
Tobacco products manufacture	Propylene, Toluene, Acetone, Styrene, 2-Ethoxyethanol, Dibutyl phthalate, Methanol	Al, As, Ba, Be, Br, Cd, Co, F, Fe, Ge, Hg, Mn, Pb, Sb, Sr, Ti, Zn, Zr, NH_3, Chlorine compounds,

Activity: Industry, Enterprise	***Organic contaminants***	***Inorganic contaminants***
Umber, Bentonite & Gypsum manufacture	BTEX, HFCs, TPH, PAHs, PCBs, Aliphatic hydrocarbons, Dioxins, Furans	Al, As, B, Be, Cd, Cl, Co, Cr, Cu, F, Fe, Hg, Mn, Ni, P, Pb, Sb, Sr, Ti, Tl, V, Zn, NH_3, NO_x, SO_x, Sulphate, Sulphide
Vegetable and animal oils and fats manufacture	Pectins, Tannins, Phenols and Organic acids, Volatile hydrocarbons	Ba, Cu, Fe, Mn, Ni, S, P, Zn, Chlorine & N compounds,
Washing and dry-cleaning of textile and fur products	BTEX, TPH, VHH, Aliphatic hydrocarbons	B, Ca, Fe, K, Mg, Mn, Na, P, Ammonium, Sulphate, Sulphide
Waste treatment plant	BTEX, MTBE, PAHs, PCBs, PCPs, TPH, VHH, Pesticides, Phenols, Chlorophenols, Dioxins, Furans, Aliphatic hydrocarbons, Chlorinated aromatic hydrocarbons, Organolead and Organotin compounds	Al, As, B, Ba, Ca, Cd, Cl^-, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, P, Pb, Sb, Se, Zn, Ammonium, Nitrate, Nitrite, Sulphate, Sulphide
Wearing apparel and accessories manufacture	1,1,1-Trichloroethane, Methyl ethyl ketone, Toluene, Dichlorome-thane, Acetone, Xylene, Tetrachloroethylene, Pesticides (screening)	As, B, Cr, Cu, Mn, Sb, Zn, Sulphuric acid, Chlorine
Wines manufacture	BTEX, PAHs, PCBs	Cu, Cr, Pb, Zn, SO_x, Nitrates, Phosphates

AOX: Adsorbable organically bound halogen

BTEX: benzene, toluene, ethylbenzene and xylene

DCM: Dichloromethane

HCB: Hexachlorobenzene

HFCs: Total mass of hydrogen fluorocarbons, *i.e.*, sum of HFC23, HFC32, HFC41, HFC4310mee, HFC125, HFC134, HFC134a, HFC152a, HFC143, HFC143a, HFC227ea, HFC236fa, HFC245ca

MOHC: Metal Organic Heat Carrier

MTBE: Methyl-Tertiary-Butyl Ether

NMVOC: Total mass of Volatile Organic Compounds

PAE: Phthalatic Acid Esters (phthalates)

PAHs: Polycyclic aromatic hydrocarbons

PCBs: PolyChlorinated Biphenyls

PCPs: 1-(1-Phencyclohexyl) piperidine

PER: Tetrachloroethylene

PFCs: Total mass of perfluorocarbons, *i.e.*, sum of CF4, C2F6, C3F8, C4F10, c-C4F8, C5F12, C6F14

SF6: Total mass of sulphur hexafluoride

TCE: Trichloroethane-1,1,1

TCM: Tetrachloromethane

TPH: Total Petroleum Hydrocarbons

TRI: Trichloroethylene

VHH: Volatile Halogenated Hydrocarbons (Trichloromethane, *etc.*)

APPENDIX 1 REFERENCES

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