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CRITERIA FOR ENVIRONMENTAL POLLUTION OF THE INDUSTRIAL AND MINING AREAS ASSESSMENT IN SPAIN

Juan GRIMA[1], Rafael GARCÍA[1]

Abstract. The European Parliament's mandate to the Commission to develop a thematic strategy for soil protection highlights the need to adopt measures that prevent, limit or reduce the impact of human activities on soil. In Spain, the Royal Decree 9/2005 of 14 January fulfils the provisions of the Wastes Law 10/1998 of 21 April, and establishes a list of potentially soil contaminating activities, and criteria and standards for declaring that sites are contaminated, a subject to prior consultation with the Autonomous Communities. The Royal Decree shall not apply to the public owned sites where military installations are located. Within a period of two years from the date on which it enters into effect, the Ministry of Defence shall approve, subject to previous acceptance by the Ministry of the Environment, a decontamination plan for such sites.
There are no legal criteria for the assessment of the environmental pollution originated from the extractive industries wastes. Any future national legislation must be based on the forthcoming Directive of the European Parliament and of the Council on the management of waste from the extractive industries. This Directive will provide for measures, procedures and guidance to prevent or reduce as far as possible any adverse effects on the environment, and any resultant risks to human health, brought about as a result of the management of waste and other extracted materials from the extractive industries.
As related to groundwater, only drinking water standards are fixed. Nevertheless, several National and European initiatives have been launched for the assessment of the chemical status of groundwater. They are based on existing Community quality standards (nitrates, pesticides and biocides) and on the requirement for Member States to identify pollutants and threshold values that are representative of groundwater bodies found as being at risk, in accordance with the analysis of pressures and impacts carried out under the Water Framework Directive (WFD). According to the Groundwater Directive (GWD) proposal, threshold values defined at national river basin district or groundwater body level would be used for defining good groundwater chemical status.

Key words: soil, groundwater, quality standards, industrial areas, mining areas, wastes.

Abstrakt. Parlament Europejski upoważnił Komisję Europejską do przygotowania strategii ochrony gleb, która uwzględniałaby kroki prewencyjne oraz odpowiednie ograniczenia i redukcję wpływu działalności ludzkiej na gleby. W Hiszpanii Rozporządzenie Królewskie 9/2005 z 14 stycznia spełnia założenia Prawa o Odpadach 10/1998 z 21 kwietnia i ustala listę potencjalnych zanieczyszczeń, a także kryteria i standardy pozwalające uznać dany teren, po konsultacji z lokalnym samorządem, za zanieczyszczony. Królewskie Rozporządzenie nie dotyczy terenów publicznych zajętych przez instalacje militarne. Ministerstwo Obrony przygotuje program dekontaminacji tych terenów, po konsultacji z Ministerstwem Środowiska.
Brak jest kryteriów prawnych dla oceny zanieczyszczenia środowiska spowodowanego przez odpady przemysłu wydobywczego. W tym przypadku dalsze rozwiązania prawne będą musiały opierać się na przyszłej Dyrektywie Parlamentu Europejskiego i Rady Europejskiej w sprawie odpadów przemysłu wydobywczego. Dyrektywa ta przedstawi środki, procedury oraz przepisy dotyczące działań prewencyjnych lub maksymalnie ograniczających możliwe negatywne wpływy na środowisko oraz możliwe ryzyko dla ludzkiego zdrowia powodowane przez odpady przemysłu wydobywczego i przez ich składowanie i wykorzystywanie.
Jeśli chodzi o wody podziemne, to ustalone są tylko standardy dotyczące wód pitnych. Tym niemniej, liczne inicjatywy narodowe i europejskie podniosły sprawę oceny chemicznego stanu wód podziemnych. Oparły się ona na istniejących jakościowych standardach Wspólnoty (azotany, pestycydy oraz biocydy) oraz na wymaganiach poszczególnych państw członkowskich dotyczących określania substancji zanieczyszczających oraz wartości granicznych, powyżej których wody

[1] Instituto Geológico y Minero de Espańa (Geological Survey of Spain)

podziemne uznawane są za zagrożone, zgodnie zresztą z zaleceniami Ramowej Dyrektywy Wodnej. Zgodnie z propozycją Dyrektywy Wód Podziemnych wartości graniczne określane w obrębie krajowych dorzeczy lub ciał wód podziemnych wykorzystywane są dla określania dobrego poziomu chemicznego wód podziemnych.

S³owa kluczowe: gleba, standardy jakości, obszary przemysłowe, obszary górnicze, odpady.

INDUSTRIAL AREAS ASSESSMENT

QUANTIFICATION OF CONTAMINATED SITES

Efforts to quantify the number of contaminated sites began in 1990, resulting in a database on contaminated soils (Inventario de Suelos Contaminados). The efforts have been carried out in phases. The first phase was carried out in the period 1991–1993 and paid for by the Ministry of the Environment. During this phase, 250 contaminated sites were placed on the list. The second phase was carried out in 1994–1995 and was also financed by the Ministry. In this phase, 120 additional contaminated sites were identified. At this stage, 18,142 industrial activities were identified and 4902 sites were considered potentially contaminated. The 370 sites, which were listed, were all been investigated, generally including the collection and analyses of soil and/or groundwater samples. The objectives of this plan were:

- to prevent further contamination;
- to continue the identification of the polluted sites;
- to investigate 1650 potentially contaminated sites;
- to remediate 274 priority sites;
- to develop clean-up technologies;
- to lay down specific national legislation and technical regulations.

The third phase began in 1995 and is still in progress. In this stage, the Ministry has made a bilateral agreement with each of the autonomous regions and will finance 50% of the work. The individual autonomous regions administer the actual investigations. In phase 3, a much larger number of sites, including landfills in many cases (Fig. 1), will be identified. For example, the region of Andalucía alone has now identified 300 new sites. It is estimated that approximately 10,000 sites will be listed when phase 3 is complete (Lopez de Velasco, 1999). At present, 11 of the 17 regions have begun or completed phase 3 and work is expected to continue during the approximately next 3 years. There exists no official time frame for the remediation of contaminated soils. The Ministry is aware that the clean up will depend on the financing available. Calculations of the cost for remediation the 370 contaminated sites are estimated to be 1.849 mill. Euro (EEA, 1997).

Fig. 1. Quantification of contaminated sites, landfills

LEGAL FRAMEWORK

The Waste Act of 1998 identifies the polluter as liable. If the polluter is unknown, the landowner is responsible. The Ministry has the option to fund a remediation and later recover the costs. Costs can be recovered either directly or by the transfer of an appropriate portion of the remediated property. Cost recovery is to take place over a 10–15 year period. The Wastes Law 10/1998 includes a mandate instructing the Spanish Government to approve and publish a list of potentially soil-contaminating activities, and establishes specific obligations that apply to the owners of activities and of properties where the specified activities are carried out or have been in the past. An integrated assessment and management of contaminated sites (García-Delgado, 2004) is, therefore, needed.

The Royal Decree 9/2005 of 14 January establishes a list of potentially soil contaminating activities and criteria and standards for declaring those sites as contaminated. It fulfils the provisions of the Wastes Law 10/1998 of 21 April, subject to prior consultation with the autonomous communities. The Royal Decree makes reference to the presence of dangerous chemical substances of human origin that are capable of altering the chemical, physical or biological characteristics of soil. They, therefore, constitute a risk that must be quantified in order to assess possible harm to human health and the environment. Future use must be assessed, so factors like, for example, rising groundwater in urban areas have to be considered (Fig. 2). Sites shall be declared contaminated by express decision if, in accordance with the standards set out in this Royal Decree, said risk is deemed unacceptable for human health and the environment.

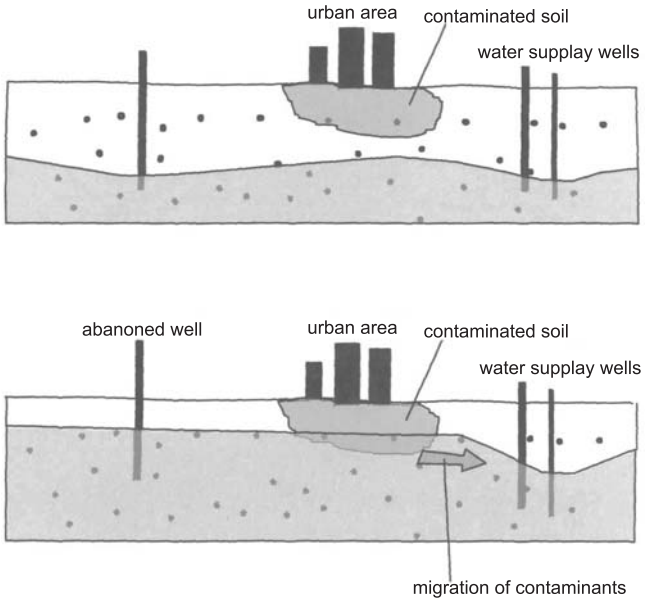

Fig. 2. Factors affecting future contamination processes

GENERIC REFERENCE LEVELS

Generic Reference Level (GRL) is the basic parameter that shall be used for assessing soil contamination for specific substances, and is defined as the concentration of a contaminant in soil that does not result in a level of risk higher than the acceptable maximum for human health or ecosystems. Standards, on the other hand, are the set of generic reference levels for contaminants of relevance for a site, established with a view to protect human health and, where appropriate, ecosystems.

CRITERIA FOR CALCULATION OF GENERIC REFERENCE LEVELS

A distinction must be made for the calculation of Generic Reference Levels for the protection of human health and ecosystems. In the first case, the determination of toxicological threshold values is based on the land use. Three basic types of land uses are defined as follows:

- industrial, which main purpose is carrying out the industrial activities, excluding agricultural and livestock-raising activities;
- urban, which main purpose is to be used for the construction of homes, offices, public facilities, and services infrastructure, as well as for recreational and sport activities;
- other land uses, which are neither urban nor industrial, and which are suited for carrying out agricultural, forestry and livestock-raising activities.

For the ecosystems protection, the following groups of organisms will be considered: soil organisms (plants, invertebrates, micro-organisms), aquatic organisms (fish, algae), and terrestrial vertebrates (birds and mammals).

Criteria for the calculation of Generic Reference Levels for the protection of human health

The determination of toxicological threshold values must be based on current and anticipated land uses. The relevant exposure pathways shall be identified and defined. The characteristics of the type of individual subject to the highest level of exposure shall be defined, and the dose shall be determined for each considered exposure pathway. Levels of exposure shall be determined using models developed by well-recognized technical, scientific or academic institutions.

The maximum admissible soil concentration for substances with carcinogenic effects (genotoxic) shall be that associated with an increased risk of cancer occurrence not greater than 10^{-5}, while for substances with systemic effects, the maximum admissible level shall be that based on the ratio applicable, in accordance with its chemical nature, between the long-term exposure dose due to soil contamination and the maximum acceptable dose.

A criterion of contiguity shall be applied, resulting in the reduction, where necessary, of levels for urban and industrial land use. According to this criterion, the reference level for urban land use may not be more than 10 times higher than the reference level for other land uses, and the reference level for industrial land use may not be more than 10 times higher than the reference level for urban land use. For synthetic substances, a reduction criterion may be applied, consisting of the adoption of a generic reference level of 100 mg/kg in cases where the calculated value exceeds this level.

Criteria for the calculation of Generic Reference Levels for the protection of ecosystems

For the determination of toxicological threshold values, toxicity tests shall include information concerning the mentioned groups of organisms. Toxicological data shall be used whenever possible based on tests carried out with protocols standardized by the European Union (EU) or the Organization for Economic Cooperation and Development (OECD). Potential bioaccumulation/biomagnification shall be obtained from field studies and monitoring of concentrations in plants, invertebrates, and vertebrates. When such information is not available, one of the models for estimating biomagnification, developed by well-recognized technical, scientific or academic institutions, shall be used. For synthetic substances, a reduction criterion may be applied, consisting of the adoption of a generic reference level of 100 mg/kg in cases where the calculated value exceeds this level.

Criteria for the calculation of Generic Reference Levels for metals

In cases where for technical or other reasons is not feasible to apply the described methodology, Autonomous Communities that have not established generic reference levels for metals may adopt those obtained by adding to the average concentra-

tion twice the typical deviation of concentrations existing in soils in nearby areas that are not contaminated and have geological substrates with similar characteristics. For the purpose of assessing soil contamination, the values calculated in this manner for metals shall constitute a single set, and, therefore, shall apply for any land use and be valid for the protection of human health, and ecosystems.

DECLARATION OF CONTAMINATED SITES

When the protection of human health is regarded as the main priority, a particular site will be declared contaminated if the concentration in soil of any of the substances listed or calculated exceeds 100 times the established generic reference level for the protection of human health in accordance with land use or when the concentration in soil at the site of any chemical contaminant exceeds 100 times the calculated generic reference level.

When the protection of ecosystems is regarded as the main priority, if the lethal or effective median concentration, $L(E)C_{50}$, for soil and aquatic organisms obtained in toxicity tests is lower than 10 mg of contaminated soil/gram of soil or 10 ml of leachate/litre of water, the site will be declared contaminated.

MINING AREAS AND MILITARY INSTALLATIONS ASSESSMENT

There are no legal criteria for the assessment of the environmental pollution originated from wastes from the extractive industries. Any future national legislation must be based on the forthcoming Directive of the European Parliament and of the Council on the management of waste from the extractive industries. This Directive will provide for measures, procedures and guidance to prevent or reduce as far as possible any adverse effects on the environment, and any resultant risks to human health, brought about as a result of the management of waste and other extracted materials from the extractive industries. The contaminated soils Decree shall not apply to publicly owned sites where military installations are located or where military activities are carried out. In the past, many military activities have been developed in industrial belts located in the surroundings of the cities. Such activities can be compared to industrial ones, and due to the growth of many cities, these sites have been absorbed and now are part of the reserves of land, required for the future development of the city.

Within a period of two years from the date on which this Royal Decree enters into effect, the Ministry of Defence shall approve, subject to previous acceptance by the Ministry of the Environment, a decontamination plan for such sites (Fig. 3), which shall conform to the technical content of the Royal Decree.

As a consequence, the Ministry of Defence is responsible for the design and preparation of a catalogue of contaminated properties to be remediated in the future. In this sense, experience of Spanish Geological Survey and national databases operated by IGME are extremely important (Fig. 4). The Spanish Ministry of Defence is the first landowner in Spain, with an estimated 1% of the whole national territory. These figures are representative of the huge task to be accomplished (Grima, García-Delgado, 2005).

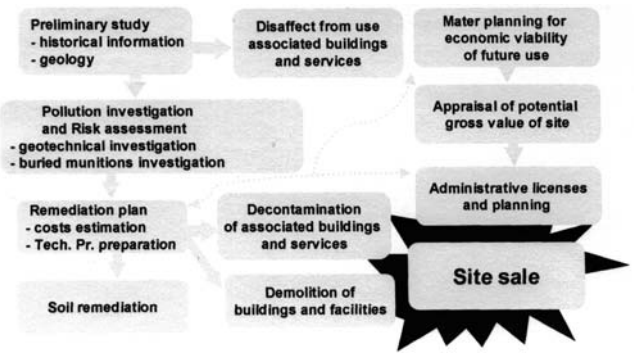

Fig. 3. Approach for the development of a military site

Fig. 4. Need of national databases for elaboration of a catalogue of military sites

In a firing range of about 69 ha, with a nominal value of 353,000 euros, a report made by IGME in December 2004 indicates a net income after remediation for Defence Ministry between 5.7 and 7 million euros

GROUNDWATER ASSESSMENT

BASIC DATA

Spain has a population of 39,242,000 (1996) and an area of 505,800 km^2. This gives a population density of 78 persons pr. km^2. The gross domestic product (GDP) in Spain is 69,780 billion pesetas (quarterly rate for 1995: OECD, 1998). The annual gross domestic product pr. person is therefore approximately 10,600 EUR.

Total precipitation in Spain depends greatly upon the region. In the coastal areas of the north and north-west, the precipitation exceeds 1600 mm pr. year. In the south-east, precipitation is around 70 mm pr. year. The values for evapo-transpiration are reversed, with high evaporation in the south (1200 mm pr. year) and low evaporation in the north (400 mm pr. year). Large areas of the country therefore have a net precipitation as low as 0 to 50 mm pr. year.

The average annual precipitation is 680 mm pr. year, while the evaporation average is 460 mm pr. year, giving an average net precipitation of 220 mm pr. year.

According to the White Book of Groundwater Ministry of Public Works, Transport and Environment (1998), the major aquifers in Spain are approximately equally divided between unconsolidated sedimentary sand aquifers and carbonaceous aquifers. In some limited areas, volcanic rocks must be used for small water supplies. This is the case, for example, on the Canary Islands.

There are 4 major basins of unconsolidated sands: Duero, Tajo (Madrid) and Ebro in the central part of the country, and Guadalquivir in the south-west. These aquifers are up to 3,000 metres thick. In the largest basin, Duero, measurements indicate a travel time from the recharge area at the edges of the basin to the river discharge at the centre of the basin of 11,000–15,000 years. This results in a saline water quality unusable for water supply in the deeper parts of the aquifer close to the discharge. In the Tajo basin, the groundwater is not capable of yielding a sustainable water supply for the large population in the Madrid area. Water table levels have fallen as much as 200 metres in some areas. The extent of the usable aquifers in the Ebro basin is limited due to the presence of low-permeable sediments. The carbonaceous aquifers are predominantly located in the eastern half of the country and generally contain younger waters. These aquifers are considered very vulnerable.

MONITORING APPROACHES

Environmental Ministry by means of Drainage Basin Authorities is responsible of the establishment of a National Monitoring Network. For control and monitoring of continental waters, there is a water quality information automatic system (SAICA). It is based in a country wide network to measure quality of waters distributed in the nine hydrographic basins, and in a database with all the information related to legislation, institutions, cartographic information of river beds, gauge stations, etc. This automatic information system allows analyzing all the data from the monitoring stations and with specific software, decisions can be taken most times in real time.

In addition of SAICA system, and accordingly with European legislation and with the Law of Waters, National Networks for piezometric, hydrometric and general quality control of groundwater do exist. At present, the Environmental Ministry is developing a project for reunification of existing networks with the aim of creating an Official Groundwater Network, managed by Drainage Basin Authorities. Presently, a number of monitoring networks are in operation:

- piezometric, with more then 3000 points and managed by Dirección General de Obras Hidráulicas and Instituto Geológico y Minero de Espańa (IGME);
- hydrometric, controlled by Drainage Basin Authorities to determine the flow of groundwater natural discharge;
- groundwater quality observation control network (ROCAS) managed by IGME to analyze major chemical components in some 1800 points;
- intrusion Observation Network, to study the evolution of marine intrusion in coastal aquifers.

There are two additional networks, the bath waters quality control, in accordance with Directive 76/160/CEE of December 1975, related with quality of bath waters, and the National Network for controlling Environmental Radioactivity in surface waters, in operation from 1978 for controlling and monitoring of several radioactive parameters.

DRINKING WATER STANDARDS

Referring to drinking water criteria in Spain, they are derived from the European Directive 80/778/CEE. European Directive 676/91C related with groundwater protection from nitrates of agricultural origin came into force in December 1991. Legal transposition in Spain was made in 1996. The limit of 50 mg/L is applied to groundwater, although in some aquifers, this figure is exceeded.

ENVIRONMENTAL QUALITY STANDARDS

In the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, paragraph 42 states:

Common environmental quality standards and emission limit values for certain groups or families of pollutants should be laid down as minimum requirements in Community legislation. Provisions for the adoption of such standards at Community level should be ensured.

At this point it is necessary to make the difference between environmental quality standards and drinking water standards.

NATURAL BACKGROUND QUALITY

Background and baseline terms have been used to define anomalous values compared to typical concentrations. Natural background can be expressed as the physical-chemical quality of water derived only from natural processes (BaSeLiNe, 1999).

Nevertheless, some topics must be addressed when using this definition. Natural Background could be defined by means of a numerical value, like the mean, the median or maximum value. On the other hand a range of values could provide a valuable indication of natural variation for a given aquifer. Moreover, it is not clear if indirect impacts from human activities should be considered as part of the natural background.

Derived from the European project Baseline, Natural Background is defined as the range of concentrations of a given element, species or chemical substance present in solution, being derived from natural, geological, biological or atmospheric sources (Manzano *et al*., 2003).

GROUNDWATER THRESHOLDS. BRIDGE PROJECT

In Spain, only drinking water standards are fixed. Nevertheless, several National and European initiatives have been launched for the assessment of the chemical status of groundwater. The Commission proposal of Groundwater Directive COM(2003)550 developed under Article 17 of the Water Framework Directive (2000/60/EC) sets out criteria for the assessment of the chemical status of groundwater, which is based on existing Community quality standards (nitrates, pesticides and biocides) and on the requirement for Member States to identify pollutants and threshold values that are representative of groundwater bodies found as being at risk (Table 1; Fig. 5), in accordance with the analysis of pressures and impacts carried out under the WFD.

Table 1

Identification of Groundwater Bodies at risk

Status	Risk	Impact	Pressures	Remarks
Bad status Groundwater Body (WFD goals not achievable)	sure risk	proven impact	proven significant pressure	
Groundwater Body at risk	risk at study	probable impact	proven significant pressure	control networks
		proven impact	unknown pressure	further characterization
Good status Groundwater Body (WFD goals achievable)	risk 0	null impact	no pressure exists	
Groundwater Body without data	not evaluated	no information	no information	

Risk not to achieve WFD: impact (chemical status) and pressures

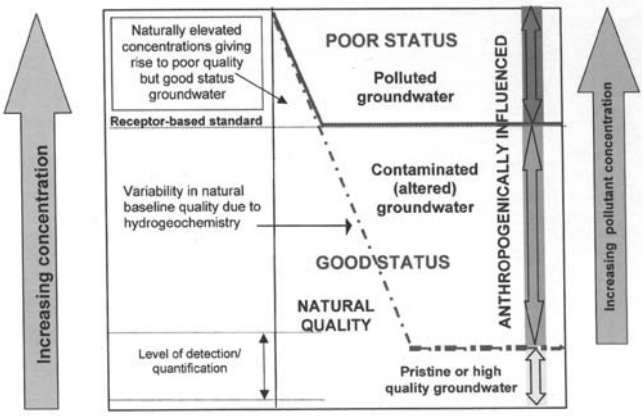

Fig. 5. General Groundwater quality relationships (from Müller, 2005)

Therefore, this objective must take into account the characterization work carried under Article 5 of the WFD. In the proposal, threshold values are to be used for defining good groundwater chemical status. The establishment of lists of pollutants in groundwater has to take account of available monitoring data and knowledge. This implies that a comprehensive survey of representative groundwater pollutants should be carried out on the basis of existing data and that additional research should be undertaken to complete these data through specific groundwater studies.

The defined topic stresses the need to provide a sound scientific basis for the establishment of representative pollutant threshold values linked to good groundwater chemical status. To get this aim, the European Commission has launched a project, called BRIDGE (Background criteria for the identification of groundwater thresholds), to be carried out at European level, involving a range of actors (research institutes, universities and governmental agencies, and links with NGOs and industrial stakeholders).

The defined time frame suggests that an identification of groundwater pollutants and related thresholds should be completed by December 2005 and that a consolidated list should be made available by June 2006, i.e. before the operational start of the monitoring programme to be undertaken under Article 8 and Annex V of the WFD. This clause refers to the proposal which will now be discussed at the European Parliament and Council level, i.e. the content of the proposal might evolve as a result of the negotiation process and the present project should not interfere with political discussions. BRIDGE is actually meant as a way to collect upstream information when practical decisions will have to be taken after the adoption of the Groundwater Directive.

The BRIDGE project (Fouillac, Müller, 2005) focuses on the development of a methodology to set out criteria for the assessment of the chemical status of groundwater and the establishment of common thresholds for pollutants in groundwater.

CONCLUSIONS

1. There are few regulations at National level to protect natural resources. Nevertheless, at the time being, three European Directives are in preparation. The Groundwater, the Soil and the Mine Waste Directives. Hopefully, all of them will come into force in a couple of years.

2. There is a lack of uniformity and absence of standardized methodologies in the European Union for investigation and remediation of contaminated sites. This is pointed out for the estimation of the European Environment Agency about the number of contaminated sites in the territory of the European Union. This figure ranges from 300,000 to 1,500,000 sites.

3. Every Member State must make an effort to characterize natural resources at National level. National databases are needed and Geological Institutes can play a leading role in this process.

4. Water Framework Directive states the need of remediation for all groundwater bodies in the European Union before 2010. Achieving these objectives seems very difficult, but the delineation of simple methodologies is the way forward in the development of policies for sustainable development.

5. Even if the statement sounds obvious, it is necessary to have in mind that it is better to prevent or reduce the risk of pollution rather than dealing with the consequences.

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