Soil pollution conclusion pdf

It's a little presumptuous for a member of the team who designed the Toolbox to hold it up as a success months after it's been released. It is not a substitute for a thorough ex post evaluation of the use and impact of the toolbox in the coming years. But building the toolkit, as far as we know one of the most ambitious attempts yet to present structured information to decision makers via the web, has taught us many lessons it's good to share. In a world undergoing an ICT revolution, reaching not only decision-makers, but local staff, NGOs and CB organisations via the web and (important) CD-ROM is rapidly becoming a reality. When such customer circles can be accessed, it is important for donors and researchers in the north and south to help package the vast mass of information available. A soft decision support system, based in IT terms on html, is a very promising strategy for this. However, such an approach must take into account the fact that no policy field is abandoned, and that there are trade-offs between global outreach and regional specificity, and between participation/interactivity and authority. The electronic dissemination of policy information must be supported through training, capacity building and back-up, and however well-designed they can go so far as to influence policy. 1: Conceptual structure in livestock-environment Toolbox Figure 2: Example of a matrix of environmental risks Industrial animal production system Poultry production (broilers and stocks) Resource risks (-) and opportunities (+) Underlying factors Land (-) Toxic levels of nutrients in soils · Poor handling of animal waste (-) Chemical contamination of soils · Poor handling of chemical inputs (-) soil contamination with heavy metals (Zinc and Cadmium) · Poor management of animal waste (-) destruction of vegetation by acid rain · Ammonia emissions from animal waste (+) improved soil fertility · Balanced application on land of poultry manure will lead to improved soil fertile water (-) pollution of surface and groundwater · Poor handling of animal waste · Poor management of chemical inputs (-) depletion of fresh water resources · Increased use of fresh water Air (-) global warming: carbon dioxide emissions, methane and nitrous oxide · Increased greenhouse gas emissions Biodiversity (-) loss of genetic diversity · Loss of local breeds (-) increased susceptibility to disease · Loss of Disease Resistance Open access peer-reviewed chapterBy Muhammad Aqeel Ashraf, Mohd. Jamil Maah and Ismail YusoffSubmitted: 20 September 2013Resed: 20 October 2013Published: 26 March 2014DOI: 10.5772/57287Environmental pollution is a burning topic of the day. Air, water and soil are polluted equally. The land is a universal sink carrying the greatest burden of environmental pollution. become contaminated in several ways. Way. is urgent to control soil pollution in order to preserve soil fertileness and increase productivity. Pollution can be defined as an unwanted change in air, water and soil physical, chemical and biological properties affecting human life, life of other useful living plants and animals, industrial progress, living conditions and cultural assets. A pollution is something that negatively interferes with the health, comfort, property or environment of the people. Generally most pollutants are introduced into the environment by waste water, waste, accidental discharges or other than those of products or residues from the production of something useful. Because of this our precious natural resources like air, water and land are becoming polluted. The basis for agriculture is Soil. All crops for food and animal feed depend on it. We are losing this important natural resource through the accelerated erosion 10 to some extent. In addition, they also cause or lead to huge quantities of waste products, sludge and other products from new waste treatment plants that even pollute water or lead to soil pollution. In order to preserve the fertility and productivity of the earth, control measures shall be taken in a Herculean manner, thereby improving the health of all living beings. Assessing the ecological risk of contaminated soil, pesticide application, alteration of sewage sludge and other human activities leading to the exposure of the terrestrial environment to dangerous substances is a complex task with many related problems. Terrestrial ecological risk assessment is not only a relatively new area of science that has developed rapidly only since the mid-1980s, but it is also complicated by the fact that, unlike most aquatic environments, the land is very often traded on private land and traded as real estate. Professional and economic differences between the interests of scientists, stakeholders, authorities, engineers, managers, lawyers, NON-GOVERNMENTAL ORGANISATIONS (NGOs) and regulators are therefore not uncommon. Even neglecting these aspects, there are a number of unresolved problems in the way we assess the risk and manage the effects of anthropogenic substances in the terrestrial environment. This chapter does not intend to present a comprehensive review of all published data from ecological studies in contaminated sites. Instead, the observations from all case studies are used in the discussion and form the basis for the final conclusion. In each case, we try to answer the following questions: What is soil contamination and how it occurs? How to determine the ecological risk assessment of the soil? To what extent do ground screening levels (over)risk estimate? Do bioassays represent a more realistic risk estimate? Is it possible to carry out sound field surveys, or do we lack appropriate reference situations? What are the possible soil methods of the contaminated soils? Soil contamination is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease-causing agents, which have adverse effects on plant growth and animal health [1]. Soil is the thin layer of organic and inorganic materials that covers the earth's rocky surface. The organic portion, which originates from the decaying remains of plants and animals, is concentrated in the dark top top soil. The inorganic part, consisting of rock fragments, was formed over thousands of years by physical and chemical weathering of the bedrock. Productive soils are essential for agriculture to provide the world with sufficient food [2]. There are many different ways that the soil can become contaminated, such as:Seepage from a landfillWaste of industrial waste in the soilCorrelating of contaminated water in the soilPurity of underground storage tanksExcess application of pesticides, herbicides or fertilizerSolid waste seeps The most common chemicals involved in causing soil pollution are:Petroleum hydrocarbonsHeavy metalsPesticideSolventsInacids in industrial waste cause serious problems in their disposal. They contain metals that have great potential for toxicity. Industrial control also emits large amounts of arsenic fluoride and sulphur dioxide (SO_2) [3]. Fluorides are found in the atmosphere from superphosphate, phosphoric acid, aluminium, steel and ceramic industries. Sulphur dioxide emitted by factories and thermal plants can make soils very acidic. These metals cause leaf damage and destroy vegetation. Copper, mercury, cadmium, lead, nickel, arsenic are the elements that can accumulate in the soil, if they are admitted either through waste water, industrial waste or mining. Some of the fungicides containing copper and mercury also add to soil pollution. Smokes from cars contain lead that gets adsorbed by soil particles and is toxic to plants. Toxicity can be minimized by building up soil organic materials, adding lime to soils and keeping the soil alkaline [4]. Organic waste of various kinds causes pollution hazards. Household waste, municipal sewage and industrial waste when left in piles or improperly disposed of seriously affect the health of humans, plants and animals severely [5-7]. Organic waste contains borates, phosphates, detergents in large quantities. If untreated they will affect the vegetative growth of plants. The main organic pollutants are phenols and carbon. Asbestos, combustible materials, gases such as methane, carbon dioxide, hydrogen sulphide, carbon monoxide, sulphur dioxide, gasoline are also pollutants. The radioactive materials such as uranium, thorium, strontium, etc. also cause dangerous soil contamination. Deposition of strontium remains mostly on earth and is concentrated in the sediments [8]. Clean-up procedures can be continuous cropping crop use of chelate changes. Other liquids waste such as sewage, sewage sludge, etc. are also important sources of soil problems. Soil pollution is often caused by uncontrolled disposal of waste water and other liquid waste resulting from household water use, industrial waste containing a variety of pollutants, outflow of agricultural products from livestock farming and drainage of irrigation water and urban run-off [9-10]. Irrigation with wastewater causes profound changes in the irrigated soils. Among various changes brought to the soil as an outlet for sewer irrigation include physical changes such as leaching, changes in humus content, and porosity etc., chemical changes such as soil reaction, base yield status, salinity, quantity and availability of nutrients such as nitrogen, potassium chloride, phosphorus, etc. Sewage sludge pollutes the soil by accumulating the metals such as lead, nickel, zinc, cadmium, etc. This can lead to the phytoxicity of the plants. Heavy metals are elements that have a density greater than five in their elementary form. They find mostly specific absorption sites in the soil where they are retained very strongly either on the inorganic or organic colloids. They are widely distributed in the environment, soils, plants, animals and in their tissues. These are essential for plants and animals in trace amounts. Mainly urban and industrial aerosols, combustion of fuels, liquid and solid from animals and humans, mining waste, industrial and agricultural chemicals, etc. contribute heavy metal pollution. Heavy metals are found in all uncontaminated soils as a result of weathering from their parent materials. Concentration of heavy metals in soils and plants is given in Table 1.Sl.NoHeavy metalHithosphereSoil rangePlants1Cadmium (Cd)0.20.01-0.70.2-0.82Cobalt (Co)401-400.05-0.53Chromium (Cr)2005-30000.2-1.04Copper (Cu)702-1004-155Iron (Fe)50,0007000-5,50,0001406Mercury (Hg)0.50.01-0.30.0157Manganese (Mn)1000100-400015-1008Molybdenum (Mo)2.30.2-51-109Nickel (Ni)10010-1000110Lead (Pb)162-2000.1-1011Tin (Sn)402-1000.312Zinc (Zn)8010-3008-100Heavy metal concentration in the hithosphere, soils and plants (Ug/gm dry matter)In agricultural soils, however, the concentration of one or more of these elements may be significantly increased in several ways, like through applications of chemicals, sewage sludge, farm slurries, etc. Increased doses of fertilizers, pesticides or agricultural chemicals, over a period of time, add heavy metals to soils that can contaminate them. Some phosphatic fertilisers often contain trace amounts of cadmium that can accumulate in these soils. Similarly, some fertilizers when applied to soils, they add some heavy metals listed in Table 2.Sl.NoFertilizerCoCrCuMnMoNiPbZn1Nitrochalk--2224-2-152Calcium0.1TracesTracesTracesTracesTracesTracestracestracestraces---13Nitrat--Till 10Till to 0.22<5Traces to phosphate0.02-130-1000Traces to 1000Traces to 2842Traces to 35Traces to 9270-30006chloride001-0-10Traces-8<0.05<1<10Potassium -37Potassium Sulfate<5<50-300 to 80Traces to .330.09<5<50<50Heavy metal content of fertilizers (ug/gm)The range of heavy metal content sludge is given in Table 3.Sl.NoHeavy metalRange (ppm)1Cadmium< 60-15002Kobalt2-2603Kronium40-88004Copper200-80005Iron6000-62,0006Manganese150-25 0007Molybdennum2-308Nickel20-53009Lead120-300010Zinc700-49,000Heavy metal content in sludge (ppm)The fate of heavy metals in soil will be controlled by physical and biological processes operating within the earth. Metal ions enter the soil solution from these different forms of combination at different rates they can either persist in solution or pass into the drainage water or are absorbed by plants growing on the soil or retained by the soil in sparingly soluble or insoluble forms. The organic matter of these soils has great affinity to heavy metals cations, forming stable complexes, thereby leading to reduced nutrient content [11-12]. Pesticides are used quite often to -control several types of pests now-a-days. Pesticides can exert harmful effects on microorganisms, as a result of which plant growth may be affected. Pesticides that are not rapidly decomposed can create such problems. Accumulation is residues of pesticides in higher concentrations are toxic. Pesticide scoensure in soil and motion in water currents can also lead to them entering food and creating health risks. Pesticides especially aromatic organic compounds do not degrade rapidly and therefore, have a long persistence period as seen in Table 4.Sl.NoPesticidePersistence time1BHC11 yrs2DDT10 yrs32.4-D2-8 weeks4Aldrin 9 yrs5Diuron16 months6Atrazin18 months7Siwazine17 months8 Klordane12 yrs92,3 6-Trichlorobenzene (TBA)2-5 yrsPersistence time for selected pesticidesMercury, cadmium and arsenic are common constituents of pesticides and all these heavy metals are toxic. Currently DDT and a number of organic chlorine compounds used as pesticides have been declared harmful and banned in the US and Uk [13-14]. This is because their residues in soils are permanent for considerable time without losing their toxicity. This has led to higher concentrations of these pesticides in vegetation, in animal meat and milk. Eventually, man has been affected. Given their weakness, organochlorians have been replaced with organophosphate pesticides that are more toxic, but leave no residues. They don't pollute the earth. The rodenticides also add soil pollution. An important method of controlling this pesticidal contamination is to increase the organic matter content of the sun and to choose those pesticides that are not persistent and do not leave any harmful Agricultural soil Föroreningpollution of ytjordpolning of underground soilJordJordsmutsförorening soilJordJordsmutsförorening industrial outflow and solid waste polulution of surface soil disturbances in soil profilePolishing due to urban activity polishing of surface soil polishing of underground soilSources that pollute the soil are twofold: Agricultural and non-agricultural sources. Figure 1 shows the different sources of soil contamination. Soil pollution comes from various sources, including agriculture and animal husbandry. Some of the agricultural practices lead to soil pollution. They are animal waste, the use of persistent pesticides, herbicides, fungicides, nematocids, etc. fertilisers and certain agricultural practices. Soil pollution of non-agricultural sources is usually the direct result of urban sprawl caused by rapidly increasing population and a rapid per capita production of waste related to our modem lifestyle. Its materials that find their entry into the soil system have long persistence and accumulate in toxic concentration and thus become sources of contamination. Some of these most important soil pollutants are inorganic toxic compounds. Sources of soil contamination [5]Soil contamination is caused by the presence of artificial chemicals or other changes in the natural soil environment. This type of contamination usually occurs through the rupture of underground storage links, the application of pesticides, and the percolation of contaminated surface water to surface layers, oil and fuel dumping, leaching of waste from landfills or direct discharge of industrial waste into the soil. The most common chemicals concerned are petroleum hydrocarbons, solvents, pesticides, lead and other heavy metals. This occurrence of this phenomenon is correlated with the degree of industrialization and intensities of chemical use. Soil pollution is any factor that impairs soil quality, consistency and mineral content or interferes with the biological balance of organisms in the soil. Soil pollution has a negative effect on plant growth. Soil pollution associated withIndiscriminate use of fertilizerIndiscriminate use of pesticides, insecticides and herbicidesUndering large amounts of solid wasteDeforestation and soil erosionIndiscriminate use of fertilizerOxygen from air and water but other necessary nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and more must be obtained from the soil. Farmers generally use fertilisers to correct soil deficiencies. Fertilisers pollute the soil with impurities, which come from the raw materials used for their manufacture. Mixed fertilisers often contain ammonium nitrate (NH_4NO_3), phosphorus such as P_2O_5, and potassium as K_2O. For example, As, Pb and Cd are currently in tracks in rock phosphate mineral getting transferred to super phosphate fertilizer. Since the metals are not degradable, their accumulation in the soil above their toxic levels due to excessive use of indestructible poison for crops. The over use of NPK fertilizers reduce the quantity of vegetables and crops grown on the soil over the years. It also reduces the protein content of wheat, corn, grams, etc., grown on that soil. The carbohydrate quality of such crops is also degraded [15]. Excess potassium content in soil reduces vitamin C and carotene content in vegetables and fruits. The vegetables and fruits grown on over fertilized soil are more prone to attacks by insects and diseases. Indiscriminate use of pesticides, insecticides and herbicidesplants that we depend on for food is under attack from insects, fungi, bacteria, viruses, rodents and other animals, and must compete with weeds for nutrients. To kill unwanted populations living in or on their crops, farmers use pesticides. The first widespread use of insecticide began at the end of World War II and included DDT (diclordifenyltrichloroethane) and gammaxene. Insects soon became resistant to DDT and since the chemical did not decompose easily, it remained in the environment. Because it was soluble in fat rather than water, it biomagnified up the food chain and disrupted calcium metabolism in birds, causing eggshells to be thin and fragile. As a result, large birds of prey such as the brown pelican, ospreys, falcons and eagles were threatened. DDT has now been banned in most Western countries. Ironically many of them, including the USA, still produce DDT for export to other developing nations whose needs outweigh the problems caused by it [16]. In general, solid waste includes garbage, household waste and discarded solid materials such as those from commercial, industrial and agricultural activities. They contain ever-increasing amounts of paper, cartons, plastics, glass, old construction materials, packaging materials and toxic or otherwise hazardous substances. As a significant amount of solid waste in cities tends to be paper and food waste, the majority are recyclable or biodegradable in landfills. Similarly, most of the agricultural waste is recycled and mining waste is left in place. The part of solid waste that is hazardous such as oils, battery metals, heavy metals from smelting industries and organic solvents are those to which we must pay particular attention. These may, in the long term, be deposited in the soil of the surrounding area and contaminate them by changing their chemical and biological properties [17]. Soil Erosion occurs when the weathered soil particles are dislodged and removed by wind or water. Deforestation, agricultural development, extreme temperatures, precipitation including acid rain, and human activities contribute to this erosion. People accelerate this process through construction, mining, cutting of timber, over pruning and overgrazing. It results in flooding and causes soil erosion. Forests and is an excellent bonding material that keeps the soil intact and They support many habitats and ecosystems, providing countless feeding routes or food chains to all species. Their loss would threaten food chains and the survival of many species. In recent years, a lot of vast green land has been converted into deserts. The precious rainforest environments in South America, tropical Asia and Africa are under pressure from population growth and development (especially timber, construction and agriculture). Many researchers believe that a variety of medicinal substances, including a cure for cancer and aids, are located in these forests. Deforestation slowly destroys the most productive flora and fauna areas in the world, which also form vast areas of a very valuable CO_2 sinking [18]. Pollution due to urbanisationPolishing of surface soils material (such as vegetables, animal waste, paper, pieces of wood, carcasses, plant twigs, leaves, cloth waste and garbage) and more non-biodegradable materials (such as plastic bags, plastic bottles, plastic waste, glass bottles, pieces of glass, stone/cement pieces) [19-20]. On a rough estimate Indian cities produce solid urban waste to the tune of 50,000 – 80,000 tons each day. If left uncollected and decomposed, they are a cause of several problems such as; Clogging of drains: Causes serious drainage problems including rupture/leakage of drainage lines leading to health problems. Obstacles to the movement of water: Solid waste has seriously damaged the normal movement of water, thereby creating problems with inundation, damage to the foundations of buildings and risks to public health. Smelly smell: Generated by dumping waste in one place. Increased microbial activity: Microbial degradation of organic waste generates large amounts of methane in addition to many chemicals to contaminate the soil and water flowing on its surfaceWhen such solid waste is hospital waste they cause many health problems. Because they can have dangerous pathogens within them in addition to dangerous drugs, injections. Pollution of underground soilUnderground in cities is likely to be contaminated byChemicals released by industrial waste and industrial wasteDistributed and partially decomposed material of sanitary wasteMany hazardous chemicals such as cadmium, chromium, lead, arsenic, selenium products are likely to be deposited in underground soil. Similarly, underground soils contaminated by sanitary waste generate many harmful chemicals. These can damage the normal operation and ecological balance of the underground soilLess soil fertilityReduced nitrogen fixationCreated erodeabilityLarge loss of soil and nutrientsDeposition of silt in tanks and reservoirsReduced crop yields in soil fauna and floraDangerous chemicals entering underground waterEcological imbalanceRelease of polluting gasesRead from radioactive rays that cause health problemsInse vegetationClogging of sewageInundation of areasPublic health problemsDissolution of drinking water sourcesSmell and emissions of gasesWaste management problemsWaste becomes unavailable to grow foodIf contaminated soil is used to grow food, soil will usually produce lower yieldsCan cause even more damage because a lack of plants on the ground will cause more erosion pollution will change the makeup of the soil and the types of microorganisms that will live in it. Thus, it is possible for soil pollution to change entire ecosystemsThe following measures have been proposed to control soil pollution. To prevent soil erosion, we can limit construction in sensitive areas. In general, we would need less fertilizer and fewer pesticides if we could all adopt the three R's: Reduce, reuse and recycle. This would give us less solid waste. Extraction and separation techniquesThe extract of the solvent is mixed with an extraction agent in general (an aqueous solution but preferably an organic solvent). Potential applications include the removal of metals such as cadmium, copper, zinc, nickel, chromium, arsenic, antimonics and lead using a mineral solution, zinc lead, organo-metallic compounds and certain cyanides using sodium hydroxide solution. Hydrocarbons and halogenated hydrocarbons can also be removed [21]. Contamination is often preferably present in the finer or coarser fraction of the soil or the organic components (e.g. humus), contamination can therefore be removed in some cases by means of a process separating the soil into fractions on the basis of specific gravity or particle size or sedimentation rate. In thermal methods, there are two ways of heat treatment; removal of pollutants by evaporation either by direct heat transfer from heated air or open flame or by indirect heat transfer, and destruction of the pollutants directly or indirectly at the appropriate temperature. The gas leaving the heater must be treated to destroy or remove any contaminants or undesirable products during combustion. A related process is current stripping where steam is injected into soil to help evaporate relatively volatile contaminants that can be water soluble or insoluble. Treatment of the soil in suspension in a suitable liquid and without slurrying and slurry are the two possible methods. In these, intimate, contact between soil and chemical is important and should often be done so that the process of detoxification is complete. Microbial therapiesThe microbial therapies seem to be more promising that can handle the entire range of organic pollutants including phenol, polychlorinated hydrocarbons, oil and oil products, dioxins, etc. There are two different ways of approaching the problems. A community of microbes already present on the site and grown in the laboratory. Strains of microbes develop in the metabolise specific chemicals. Excavation of the soil before treatment offers the greatest scope to create optimal conditions. The excavated soil can be placed on thin layers to different depths using standard soil movement techniques and microbes and nutrients applied using standard agricultural techniques such as fertilization, plowing, outrageous, etc. Reduce chemical fertilizers and pesticide useApply bio-fertilizers and fertilizers can reduce chemical fertilizers and the use of pesticides. Biological pest control methods can also reduce the use of pesticides, thereby minimising soil pollution. Materials such as glass containers, plastic bags, paper, fabric, etc. can be reused at household levels instead of being discarded, reducing solid waste pollution. Recycling and recycling of materialsThis is a reasonable solution to reduce soil pollution. Materials such as paper, certain types of plastic and glass can and are recycled. This reduces the volume of waste and helps conserve natural resources. For example, recycling a ton of paper can save 17 trees. Control of soil loss and soil erosion can be tried by restoring forest and grass cover to control wastelands, soil erosion and flooding. Crop rotation or mixed pruning can improve fertility in the soil. Appropriate methods should be adopted for the management of solid waste management. Industrial waste can be treated physically, chemically and biologically until they are less hazardous. Acidic and alkaline waste should first be neutralized; the insoluble biodegradable material should be allowed to degrade under controlled conditions before disposal. As a last resort, new areas for the storage of hazardous waste should be explored such as deep well injection and safer landfills. Burying the waste in places away from residential areas is the simplest and most widely used solid waste management technique. The main objective of soil monitoring is to prevent and mitigate contamination by substances with the potential to exert a negative effect on the soil itself, on soil, air, water and organisms that may contact the soil. Soil monitoring, under the approval programme, is mainly aimed at the assessment of pollutants released to the earth's surface. Thus, installations below the surface are generally not the cause of soil monitoring, but may be the cause of groundwater monitoring [22]. However, if soil pollution is known or suspected to come from subsurface sources such as underground tanks or pipes, an assessment will be required. If the above considerations indicate soil monitoring is required as a condition for approval, the proponent is required to implement the following, as set out in the Land Monitoring Directive: > prepare a proposal for soil monitoring; > approved ground monitoring plan. > > and report the results of the soil monitoring, and > and implement a soil management plan setting out the results of the soil monitoring. This guideline provides a background for the soil monitoring programme and a description of the soil management programme requirements. The soil monitoring programme, which has mostly been developed under environmental protection in support of the following principles: > development must be sustainable, which means that the use of resources and the environment must not, today, impair the prospects for their use by future generations; > the environmental impact of development must be prevented or mitigated. > polluters should be responsible for paying for the costs of their actions. > costs should be incorporated into the financial planning so that sufficient funds are available for site cleanup and planners can know the real costs and benefits of source reduction programs. Recognising that, under environmental protection, a shared responsibility follows, both the holder of the approval and the department must have a way of assessing environmental performance with respect to the above principles and requirements. Environmental protection expects that approval holders will manage their activities to prevent the release of substances to the ground. However, substance emissions to soil occur, and pollutants are often present above background concentrations at industrial plants. In view of this, environmental protection should have soil quality standards as a guide for the assessment and remediation of soil pollution. Installations that are currently uncontaminated are able to maintain conditions that allow unlimited land use. For these installations, the minimum standards will be set by the Tier I criteria or equivalent targets. However, older plants were often operated according to different standards and environmental management practices than is currently acceptable. There is an increasing use of risk-oriented policies to deal with the local effects of soil pollution. The risks that such a policy addresses are: health risks to humans and may also include ecotoxicological risks. These risks are expressed in terms of negative effects and chances between 0 and 1 that such adverse effects will occur. Examples of areas where risk-oriented policies are applied to soil pollution are the United States of America [23], Canada [24] and countries in the European Union [25]. Historically, these risk-oriented policies have followed the abandonment of policies aimed at restoring soils to their original clean state. Risk-based criteria or standards developed within the framework of risk-oriented policies are applied to risks estimated by deterministic methods, following the steps in hazard characterisation, valuation of exposure and risk characterisation, while at the same time maintaining exposure-risk relationships established Risk-based criteria have been applied to land remediation decisions in the form of soil clean-up standards [26], to the use of end-use soils and in the United States also for sediment management [27]. The risk-oriented policy addressed here [28] assumes that background exposure to pollution does not present a risk and that a specified level of soil contamination poses a maximum tolerable or maximum acceptable risk to organisms living locally. The latter is the main basis for the default setting. In part, risk-oriented legislation on soil pollution includes qualitative policy objectives [29]. For example, the primary UK legislation on contaminated land defines soil as contaminated in need of risk management if significant damage is caused or there is a significant possibility that such damage is caused [29]. For the most part, the policy has led to specific quantitative values for maximum tolerable or acceptable soil pollution. The analysis of such values used in different industrialised countries has shown that there are very large differences, about up to a factor [30]. According to Provoost and others [31], these differences are largely due to different policy choices (e.g. including or excluding ecotoxicity) and in different assumptions about the modelling of exposure to soil pollution, including area-related factors, such as soil type and building structures [31]. In practice, there are several issues that have been involved in the proper establishment of the actual risk associated with a soil contamination. These are: the lack of pollution standards, neglect of background exposure, and neglect of pathways of exposure to soil pollution, neglect of available dose-effect studies and neglect of biological availability. These will now be discussed in more detail. Lack of quality standardsWhen soil contamination data are available, they should be compared with quality standards reflecting the maximum tolerable risk of exposure. However, such standards are not always in place. For example, of the volatile organic carbon compounds discovered in groundwater samples by the U.S. Geological Service, were unregulated- without any standards in place [32]. Similarly, Patterson et al. [33] found a variation of brominated ethenes in Australian groundwater, all of which lack normal. Background exposure neglectFor an accurate estimation of soil pollution-related risks, exposure to specific soil pollution should be evaluated in combination with exposure to the same substance not related to local soil contamination. A number of countries, such as Canada, Germany, Spain and Belgium, do indeed establish standards for soil clean-up, while the background diet and inhaled exposure are considered, but others, such as the land, are not covered. Neglecting background exposure or specific types backwards sex exposure may have for risk estimates. Neglect of exposure pathways to soil pollutionWhen evaluating exposure to soil pollution, assumptions about routes of exposure are important. In this respect, the difference between countries can be noted. Soil clean-up standards for lead by Norway and Sweden differ in part because the dominant route of exposure in Sweden is assumed to be drinking water and in Norway it is believed to be of drinking water and ingestion of soil [34]. Inhalation of household dust and soil particles is not always taken into account in state decision-making on the risks of soil pollution. In the Netherlands, for example, inhalation of soil particles has been neglected as a route of exposure, but in the case of the european union, for example, in The Netherlands, the introduction of soil particles has been neglected. Neglect of inhalation appears at variance with existing studies. Nawrot et al. [35] has studied the effects of cadmium pollution in soil (around former thermal zinc plants) and found a significant increase in lung cancer risk correlated with cadmium exposure. They reasonably explain this in terms of exposure of lung tissue to cadmium found in inhaled soil and household dust particles. Dust particles from households have also been shown to be important for children to be exposed to pesticides in agricultural environments. Neglect of available dose-effect studiesAkesson et al. [37] has analyzed the effects of low environmental cadmium exposure in an epidemiological study of Swedish women in the Lund area, which is 53-64 years old, excluding women from areas with soils heavily contaminated by cadmium. Akesson et al. [37] found correlations between the internal dose of cadmium and tubular and glomerular kidney effects, which may represent early signs of adverse effects. Women with diabetes seemed to have an increased risk of experiencing such early signs. In view of these data, it seems reasonable that, in the case of a background exposure common in Sweden, old women in the population may generally be at risk of negative cadmium effects [34] and that even a modest increase in cadmium exposure due to contaminated soil may lead to an increased risk. However, in setting soil clean-up standards in Sweden, this background exposure has been neglected [34]. Nawrot et al. [35] has studied the relationship between mortality and cadmium body burden in Belgium. They were evidence that total mortality and non-cardiovascular mortality may be heightened by cadmium body burdens that can be found among the population not living on soils currently considered a health risk. Similarly, there are now strong indications that the negative effects of lead on the neurophysiologist and sexual development may well be found at the level of background exposure common in Western And US cities [37], although soil pollution policy, at least in European counties, presupposes that such background exposure is safe [14]. Maximum acceptable or maximum tolerable usually derived from a limited number of studies involving single species under laboratory conditions. Laboratory conditions can be very different from actual conditions in the field, and thus the results in the field are often in variance with laboratory studies [35]. Field studies have found that several factors that tend to be neglected in laboratory studies can strongly influence the toxic effects of soil pollution. These include: density and adaptability of populations of affected organisms, the presence of other environmental impact factors and the presence or absence of specific landscape elements such as buffer strips [35]. Biologically available pollutants determine the risk [3]. Biological availability can vary greatly for different types of organisms [36]. The biological availability of a compound in a specific soil also depends on physical, chemical and biological and spatial factors [35]. Examples of such factors are pH, the amount and nature of organic and mineral compounds also present and the presence of organisms capable of mobilising soil pollution [37-39]. In practice, biological availability can be very much in variance with total concentrations [40]. Limited presentation of combination effectsA to the overall risk of soil contamination, cumulative effects of the combination of substances present in soils should be considered. However, the actual default setting practice has largely focused on criteria relating to an element or association. In some cases, there are criteria for groups of associations [34]. Such criteria limit the amount (in g/kg soil) of groups of compounds but often do not address the possibility that the risk per unit of weight may be different for different compounds. An exception to this is criteria for the presence of halogenated dioxins and benzourans and planarbiphenyles. The determination of the risk of exposure to these compounds uses supplements on the basis of equivalent toxicity [40]. This is a major improvement, although it has been pointed out that this approach may still underestimate the risk of neurodevelopmental effects [41]. The importance of combination effectsCombination effects can be important in two respects. Firstly, co-existing soil pollution can affect each other's biological availability [43]. Secondly, exposure to a combination of pollutants may be associated with antagonistic, synergistic and additive interactions of these pollutants, which affects their effect on organisms [44-47]. Some risks of contaminants mixtures can be predicted on the basis of existing knowledge. For example, there is a reasonable chance that there will be dose additivity when effects are receptor mediated [48]. Even in the case of narcotic effects, ecotoxicological effects with joint mixing can be predicted [48]. If the answers are different, used [49]. A methodology for managing the ecotoxicity of mixtures ecotoxicity both dose-additive and response-additive effects have been proposed [48]. This two-step model evaluates mixing toxicity for the same mode of action with concentration additivity and the toxicity of different modes of action with response additivity. To determine the severity of the ecotoxicological effects on heavily contaminated soils (in which legal maximum tolerable levels for one or more substances are exceeded), a systematic approach to combination effects based on a mixture of concentration additive and response additive has been proposed [41]. Measures appear to be possible, which would allow a significant improvement in risk estimates. Unregulated substances can have standards. Standards can be regularly updated on the basis of new dose-effect studies. Risk estimates may include both background exposure and all routes of exposure to local soil pollution. Biological availability estimates can be integrated into risk assessments and improved by better testing of bioavailability or by in-vivo monitoring [51]. The deficiencies in the taking into account of combination effects in ecotoxicity, discussed in sections, can be addressed by direct testing of ecotoxicity, when the focus is on the functioning of the ecosystem [52,53]. However, it should be noted that small effects on the functioning of ecosystems can have significant effects over time [35]. This necessitates a large number of replicate certificates which may well be beyond routine route [35]. In determining combination effects on human health, direct human testing is an unethical option. However, biomarker-based monitoring of certain aspects of soil pollution that are relevant to humans may be an option. For example, Roos et al. [54] has applied a biomarker based test on native and remedied soils contaminated by a variety of PAHs. The tested expression profile of cytochromes P 450 [54]. Xiao et al. [55] has measured the genotoxic risk of soil contamination using an in-vitro analysis with Salmonella. Although the relationship between biomarker-based data collected and in vivo risks awaits further clearance, the application of tests based on soil pollution biomarkers is an interesting option for managing combination effects in humans. Estimates of the risk can also be derived from biomarkers that can be monitored in people exposed to soil pollution. Such biomarkers have emerged from epidemiological studies taking into account the combined effect of substances. An illustration of this is the study of Lee et al. [56] found a graduated connection of the concentration of lead and urinary tract cadence concentrations with oxidative stress related markers in the US population. This suggests that oxidative stress may be useful as a biomarker for combination effects. It has also evaluate the effects of exposure to nitroarener by measuring hemoglobin hemoglobin [57], and of mixtures of volatile organochlorolinesby measuring glutathione-konjugative metabolites [58]. Bioassays based on aryl hydrocarbon (Ah) receptor mediated mechanisms have been proposed that will allow a better alternative to measurement of polyhalogenated aromatic hydrocarbons [41]. Another option is to estimate the risks to human health by taking into account cumulative combination effects in line with established cause-to-effect relationships and research into the effects of actual combinations. It has been shown that risks to compounds with the same objective and the same mode of action can be estimated on the basis of concentration additives, while including toxicity equivalence factors for the compounds involved [59]. This has been shown to apply to receptor-mediated and reactive toxicity mechanisms, provided that no chemical reactions occur between the components of the reputable mixture [60]. Currently, this approach is applied to halogenated dioxins, benzourans and planar polyphenols, although non-linear interactions are not entirely absent in this category of compounds [61], and neurodevelopmental effects may be underestimated, as pointed out before [41]. Extension of this approach is possible to e.g. polycyclic aromatics, including heterocyclic polycyclic aromatics [18,62] organophosphates inhibiting the enzyme choline [44,63], compounds binding to estrogen receptors [64-66], carcinogens [67], a variety of petroleum products [68] and compounds inhibiting the MXR efflux pump [69]. Ecological risk assessment (ERA) is a process for collecting, organizing and analysing environmental data to estimate the risk or likelihood of undesirable effects on organisms, populations or ecosystems caused by various stressors associated with human activities. The basic principles of ecological risk assessment are described in several papers [70-72]. All varieties of ERA are associated with uncertainties. The value or benefit of the different ERA methodologies depends on the uncertainty, predictability, benefits and costs. There are typically two major types of ERA. The first is predictive and is often associated with the authorisation and handling of dangerous substances such as pesticides or new and existing chemicals in the European Union. This type of ERA is preferably done before environmental release. The second type of era could be described as an impact assessment rather than a risk assessment, as it is the assessment of changes in populations or ecosystems in areas or areas that are already contaminated. The predictive method is based on more or less generic extrapolations from the laboratory or controlled and manipulated semifield studies to real-world situations. The descriptive method is more site-specific as it seeks to monitor ecosystem changes in contaminated soils such as old landfills or gas installations or in field areas after pesticides or sewage sludge. Often ERA is performed in phases or levels, which can include predictive as well as descriptive methods. The successive levels require, as a rule of thumb, more time, effort and money. The paradigm or systems of ERA can vary significantly from country to country, but often consist of an initial problem formulation based on a preliminary site characterization, and a screening assessment, a characterization of exposure, a characterization of effects, and a risk characterization followed by risk management. Although exposure assessment is often equally or even more important, this chapter primarily takes into account efficacy assessment. In most European countries, ERA consists of contaminated soils of fairly simplified methods including soil screening levels (SSL) (a.k.a. quality objectives, quality criteria, benchmarks, benchmarks) and simple bioassays for an initial risk control [73-75]. National research or clean-up programmes have led to a large number of benchmarks producing a large number of benchmarks. Although it is difficult to categorize, most fall into two categories: generic or website specific. While the site-specific guidelines require a characterization of pH, organic matter, etc., on-site, generic guideline values are more independent of modifying factors and thus easy to legislate. Three major classes of tools for assessing ecological effects can be identified: standardised ecotoxicity experiments with single species exposed under controlled conditions to single chemicals impaled to soil; ex situ bioassays, here defined as simple laboratory analyses where individual species are exposed to historically contaminated soils collected in the field. and finally monitoring, analysing, and mapping the population or community structures in the area. Furthermore, mesocosm, lysometer, or terrestrial model ecosystem (TME) may be useful; these can be considered as a large (multispecies) bioassays or ecotoxicity tests [76-79]. TSE has the advantage that they work with the (relatively) undisturbed inherent soil populations that make up a small food web. TME thus allows the assessment of the effects of toxicants media emanating through changes in food security or competition and predation. One of the keystones in deriving environmental quality criteria is the use of standardized terrestrial testing procedures. The emphasis of these prognostic tests is on reproducibility, standardization, international acceptance, and location independence. Although the number is increasing, relatively few terrestrial tests are still approved by the International Organisation for Standardisation (ISO) or the Organisation for Economic Cooperation and Development (OECD). However, other tests have shown promising results and are likely to be prepared for standardisation in the future [80]. However, the major problem with using laboratory tests to extrapolate extrapolate contaminated soil used for years is not be the limitations of the tester and the natural variation in species sensitivity. The problems associated with extrapolation from one or a few species, exposed under controlled and typically optimal conditions, to the complex interaction between species and chemicals found in most polluted ecosystems should also cause concern. Although the laboratory tests of individual species with impaled materials have their obvious advantages, e.g. in the field of human health and the environment, the use of the risk of Bioassays, defined in this context, is one of the more frequently used higher-level options. Basically, the same test species can be used in bioassays to assess the risk of a specific contaminated soil as in standard laboratory tests. However, bioassays have the advantage, compared to the use of spiked soil samples, that the exact toxicity of a specific soil can be directly achieved: this includes the combined and site-specific ecotoxicological effect of the mixture of impurities and their metabolites. Furthermore, in situ bioavailability of the specific soil (at least almost) is maintained in the laboratory during the exposure period. Several studies have shown a decrease in bioavailability and/or toxicity of soils with an ancient history of contamination [80-85]. Bioassays are therefore often considered a more realistic tool than generic soil screening levels based on spiked laboratory soils. However, a number of uncertainties or problems may be encountered in connection with the use of bioassays and the interpretation of their results. Firstly, the test species are still exposed to the pollutants for a relatively short period compared to the permanent exposure condition present in contaminated sites. Furthermore, they are exposed under more or less optimal conditions, in that stressors such as predation inter- and interspecies competition, drought, frost, and food depletion are eliminated during exposure. Finally, only a few species are usually tested individually. To compensate for some of the limitations just described, contaminated soil can be assessed using multispecies mesocosms, lysometers, or TME. In these, species interactions can be evaluated by manually inserting several species into the systems or monitoring the earth's intrinsic populations. Natural climatic conditions may be included if the test system is kept outdoors. However, if we want to get a more realistic and large-scale picture of the impact caused, for example, by the use of pesticides or sewage sludge, or for assessing environmental health in waste areas, industrial areas or gas works, it is often necessary to carry out some form of field observation. There are several case studies where field studies have successfully clarified the ecological risk of specific activities or the ecological impact of [85-87]. The small enartsbioassay, large multispecies TME, and field surveys have some drawbacks in common. First of all, it can be difficult to actually link the observed effect to a specific toxic component in the soil. Which of the many substances actually causes the majority of the effects observed, or is it perhaps a combination of effects? For a hazard classification of soils or a ranking of soils, this may not be so important. However, in order to evaluate potential risk mitigation measures or risk management procedures, it may be important to identify the most problematic substances. A comparison of soil screening values with measured concentrations for each chemical present in a site may be helpful in identifying the most likely group of substances causing the observed effect. Other possible tools may be a toxicity identification and evaluation (TIE) [88]. The TIE method is a relatively new method, which aims to identify groups of toxic substances in soils with mixed impurities. Potentially toxic components present in the soil are fractional and determined, and the toxicity of each individual fraction is determined by a Lux bacterial-based bioassay or Microtox bioassay. Although it may be promising, TIE is a time-consuming and therefore costly procedure that is not yet routinely used. Another crucial issue when analyzing the results of bioassays, TME, and field studies is the presence or absence of a proper reference site or soil. The control soil should in principle resemble the contaminated soil in all relevant parameters, e.g., texture, pH, organic matter, water retention capacity, and nutrient content, a practical problem that is very often difficult to solve. However, the lack of adequate control or reference points can be at least partially conquered by the use of multivariate techniques [89], which relate to the composition of species and the abundance to pollution gradients. It is not the intention of this chapter to present a review of statistical tools for ecological risk assessment, and thus there is no detailed discussion on their use. The eight steps of the US-EPA framework for risk assessment of contaminated super fund facilities. However, DQO = data quality targets [89]It is clear that increased computing power and the presence of new easy-to-use software tools have increased the ability to move away from more conventional univariate statistics such as variance analysis (ANOVA) to more powerful multivariate statistics that use all collected data to evaluate effects at a higher organizational level. Statistical methods such as efficacy analysis can also be very useful in planning and designing large-scale ecotoxicity studies such as mesocosms, TME, or field studies. The US-EPA has published a guide for ecological risk assessment, which should be assessment of risks at Superfund facilities. Since all sites are is unique this should always be done in a location-specific way. The ERA process proposed by the US-EPA for Superfund sites follows an eight-step process, which can be divided into four categories, i.e. 1) planning and scope, 2) problem formulation, 3) stress response and exposure analysis, and 4) risk characterization. A negotiation and agreement on the need for further action between the risk assessor, the risk manager and other stakeholders, the so-called scientific management decision points (SMDP), is essential for all steps. The SMDP made at the end of the screening level assessment will often not be a first clearance target. Instead, hazard quotas, derived in this step, are used to help determine potential risk. Therefore, requiring a clean-up based solely on those values would not be very likely, even if it is technically feasible. There are three possible decisions at the SMDP: There is sufficient information to conclude that ecological risks are very low or non-existent, and therefore there is no need to clean up the site on the basis of ecological risk. The information is not sufficient to take a decision at this time, and the ecological risk assessment process will continue. The information indicates a potential for negative ecological effects, and a more thorough study is necessary. In the Netherlands, contaminated sites are first determined by means of a set of soil screening levels known as target and intervention values, which take into account both human and ecological risks. In heavily polluted areas, clean-up or other land management decisions are required if the risks cannot be neglected based on a site-specific ecological and human risk assessment. So far, the ecological risk assessment has been based on chemical analysis, including a decision Table that accommodates critical dimensions of the affected area. The United Kingdom and Canada have also developed a framework for ecological risk assessment of polluted land. A cornerstone of the UK era framework is the adhering to the statutory land identification and control system potentially affected by contamination. The British framework is based on systems set out in, for example, the European Parliament and the Council. Like these, it is one based on a differentiated approach in which the original Tier 0 aims to determine whether a website falls under Part IIA of the legislation. It is about the development of a conceptual site model (CSM), which described what is already (historically) known about the site, eg. The conceptual location model is followed by an initial screening phase (Tier 1) and an actual site-specific characterization (Tier 2). Tier 1 is a simple deterministic comparison of chemical residue data and soil quality guideline values supplemented by simple soil specific The final (Tier 3) involves more detailed in-situ studies and, for example, ecological modelling based on a more advanced ecological theory. Tier 3 is unlikely to be implemented in many locations. Ecological risk assessment is often a complex process with many variables to take into account. ERA involves many stakeholders and all must be dealt with in a clear and consistent manner. A step-by-step or differentiated approach is therefore useful for overcoming the complexity of an era area. To structure all information collected, a decision support system (DSS) can be used. Each level will lead to a decision to move on or to stop. A number of decisions supporting systems or frameworks have already been developed in other countries, such as DSS presented here based on basic principles that are also connected to the methods used in the US and UK. However, in the present DSS measure of bioavailability and use of the Triad method can be built into the system more systematically. This chapter presents the overall framework for a new DSS including the Triad strategy and the challenge of weight and scale results used in this process. Rutgers et al. (2000) developed a basic flowchart for ecological risk assessment [90], which is used as the backbone of the decision support system (DSS) presented in Figure 5.DSS is separated into three different stages, i.e. Stage Ⅱ. determination of ecological aspects. Step III. Location-specific level-based assessment (the Triad):– Tier 1. Simple screening– Tier 2. Refined screening– Tier 3. Detailed assessment – Tier 4. Final assessment. Each of these four levels is based on a weight of evidence (WoE) approach that combines three lines of evidence (Chemistry, (eco)Toxicology and Ecology). The DSS in this chapter is not a complete and comprehensive document for managing the risk of contaminated land. It focuses strongly on supporting decisions taken when considering risks to the terrestrial environment. Therefore it addresses only indirect risk to groundwater and water associated (connected) fresh water systems. Nevertheless, information on, for example, reduced bioavailability may be useful in assessing the potential risk of leaching pollutants into groundwater or surface water. Furthermore, it is important to recognize that the management of a contaminated site is more than assessing ecological risks. Issues such as risk to human health, technical feasibility and costs of clean-up solutions, development plans for the victim or the region are equally important. Basic flowchart for ecological risk assessment [90]The first step in DSS is to determine what is often called a Conceptual Site Model. It aims to involve as many stakeholders as possible in order to describe the characteristics of the site and to review all available information from the site, such as the location of the site. on land use, investigation of whether the site can be regulated under specific directives, obvious data gaps and urgency for reaction and data collection. The spatial boundaries of the site should be defined and the current and future land use should also be defined. Consultations between administrators, planners and experts must therefore take place as early as possible in the process. The first requirements of the DSSAn investigation among all interested parties should be implemented as one of the first initiatives. The aim should be to collect as much information on soil characteristics as possible. The first of these measures to be taken among all stakeholders is to decide what land use is required for the site, as this will determine the necessary data collection and testing. Many land uses can be defined, but in general the four following horizontal categories of land use classes are used:industrial area (including infrastructure and paving).urban/residential (including recreational and green areas).agricultural area.natural area. When is an ecological risk assessment needed? Most often, a site-specific ERA will only be initiated when soil concentrations exceed ground screening levels. However, this is perhaps not in itself a sufficient criterion to go through the whole ERA procedure. Certain sub-conditions, based on the current and future types of land use, the level of pollution and various ecological considerations, must be met in order to rationalise an era.) The experts and other interested parties should answer a number of simple questions in order to conclude whether the required limit conditions are met. In Stage II, site-specific ecological characteristics and receptors related to the land use defined in Stage I must be described. This includes aspects such as key species and life support functions. The potential ecological receptors should be identified to determine whether potential source-way receptor links can be established. This includes not only organic receptors directly linked to the area, but also those indirectly linked, for example, by leaching pollutants to connected fresh water systems or (migrating) birds or mammals feeding in the area. Table 9 gives some examples of land use and related ecological aspects. This table can be used as a starting point for the choice of ecological aspect. Experts from ecotoxicology and ecology should be involved in the selection of ecological aspects. If, after completion of Phase I and Stage II, it is still considered that there is a need for a site-specific evaluation of ecological risk, the process continues to Stage III using the weight of evidence method described below. In order to address conceptual uncertainties in a pragmatic way, it has been proposed to use the importance of evidence (WoE) approach in [90–93]. The logic, as in fairness, is that many independent independent to come to a conclusion will provide stronger evidence of ecological effects, making era less uncertain. In the sediment research area, the application of WoE started at an early stage and was called the sediment quality triad. For terrestrial ecosystem swords WoE and triad are still in a spirit stage. The Triad method is based on the simultaneous and integrated dissemination of site-specific chemical, toxicological and ecological information in the risk assessment set out in Figure 6. The great assumption is that, in three independent disciplines, WoE will lead to a more precise response than an approach, based solely on, for example, concentrations of pollutants on the ground. A multidisciplinary approach will help to minimize the number of false positive and false negative conclusions in era. It also acknowledges the fact that ecosystems are too complex to analyse in one-factor approaches. Schematic presentation of the integration of three research fields according to a Triad [92]Chemistry: The concentration of pollutants in the environment (totals, bioavailable), accumulated in biota, or modelled via food chains is used for the calculation of risks on the basis of toxicity data from the literature. Toxicology: Bioassays with species across the genera are performed to measure the actual toxicity found in environmental samples from the site. Ecology: Field ecological observations at the contaminated site are compared to the reference site. Deviations from the reference site, which can reasonably be attributed to pollution levels, are channeled into the Triad.Triad is a powerful weight of evidence approach originally developed to evaluate sediment quality. In the terrestrial compartment smaller experience is available on the practical use of the Triad. This chapter describes the use of the Triad in more detail and provides an insight into some of the important decisions risk assessors must make when performing the Triad in practice, such as how to scale, weight and integrate the results of the various investigations. The triad approach exists of three lines of evidence (LoE), the so-called Triad leg, ie. The Triad method includes a tiered system in which each successive level is increasingly fine-tuned to the location-specific situation. In the first level, research is simple, broad and generic. In later levels more specific and complex tests and analyses may be used. For each of loe in the Triad there are a variety of analyses or tests that can be selected. Some examples are:Chemistry: Measurement of total concentrations, bioavailable concentrations, bioaccumulation, etc. Toxicology: Bioassays (in fields and/or in labs), biomarkers, etc. Ecology: Field observations of vegetation, soil fauna, microorganisms, etc. In Chapter 6 have a number of tests or which are too suitable for use in each level are presented for the chemistry, toxicology and ecology loe.This chapter is an attempt to present a decision support system, which can guide risk assessors in their assessment of site-specific ecological risk. A number of site-specific questions need to be answered before a final decision to carry out an ecological risk assessment can be made. This chapter introduces a flowchart for ecological risk assessment of contaminated sites. The flowchart is presented as a decision tree as shown in Figure 8, together with a more in-depth introduction to the relevant issues that need to be addressed and answered when a site-specific assessment of ecological risk is carried out. The assessment of ecological risk is carried out in stages in levels. Higher levels gradually represent more and more complex studies, but also more expensive and labor-intensive studies. The full site-specific risk assessment covers four levels, i.e. Simple screening: Tier 1.Refined screening: Tier 2.Detailed assessment: Tier 3.Final assessment: Tier 4.The main principle in moving from a simple screening across a more refined screening to a detailed assessment of the contaminated area is to minimize time and effort. The actual results of the risk assessment and the use of the different levels can be very site-specific. Tier 1 — Simple screeningAfter deciding in the first two stages of ERA that ecological concerns need special consideration, the risk assessment typically begins with a simple evaluation at the screening level. This is done to minimize costs until new information indicates the need for further assessment and more sophisticated studies. Therefore, the tools used in the first screening need not only be reasonably quick and simple, but also relatively inexpensive. The tools for use in Level I are described in more detail in the toolkits C1, T1 and E1. On the basis of the results of instruments used in Tier 1, it is decided to either stop further assessment or continue to a higher level. Tier 2 — Refined screeningTier 2, still considered at screening level, aims to refine the measurement of exposure while providing further insight into the toxicological and ecological properties of the contaminated soil. Tier 2 deviates from the conservatism normally associated with the use of total concentration in the risk assessment by taking into account (rough) estimates of bioavailability in the chemical LoE. A better screening of the toxicological and ecological properties of the soil compensates for the reduced conservatism in the Triad's chemical lobe. The tools for use in Tier 2 are described in more details in the C2, T2 and E2 toolkits. On the basis of tier 2 results, a decision should be taken either to stop further assessment or to proceed to a higher Tier.Tier 3 - Detailed assessmentTools in Tier 3 from those used in Tier 1 and Tier 2 in that they are more labor-intensive, costly and can take longer. On the other hand, they are (often) more realistic and/or ecologically relevant in order to provide a more comprehensive assessment of the ecological risk at the specific site. Interested parties should negotiate in advance a minimum set of tests. It is necessary, for example, to consider all trophic levels in the toxicological and organic LoE? Or does land use suggest something else? Is it necessary (or possible) to estimate the bioavailability of all the substances that exceed their SSL? If not, how are the substances not examined handled? The tools described for use in Tier 3 are described in more details in the C3, T3 and E3 toolkits. Depending on the results of Tier 3 a decision should be taken to either stop further assessment or continue with an even more detailed assessment in Tier 4Tier 4 — Final assessmentIn Tier 4, the purpose of the studies is to answer any remaining questions and to reduce existing uncertainties and this may often require in-depth research. Tier 4 tools may be similar to Tier 3 tools, but more focus needs to be on location-specific circumstances. For example, bioassays should be done with organisms, which normally occur on the site. Furthermore, it may be more relevant to consider ecological effects outside the contaminated area on, for example, predators or herbivores feeding in the area or effects in adjacent fresh water systems. This level requires specialized knowledge and experience of ERA, which means that the costs can be high and only a limited number of people can perform the tests. Generally, only a very limited number of site evaluations will include studies at the level of Tier 4. At each level, there are basically two possible solutions. Accept the risk and leave the contamination or remove (parts of) contamination. For each of the three Lines of Evidence (LoE) in the Triad different methods or tools are available. To facilitate the selection of suitable tools in the right context, the tools have been compiled into subclasses or toolboxes. Each of these is a collection of tools that are considered potentially useful in the designated levels and LoE of the Triad, i.e. chemistry, toxicology and ecology. Furthermore, the tools are arranged according to their complexity, price and practical feasibility or in other words depending on whether they are most useful for screening or detailed assessment, i.e. Toolbox C1. Chemistry tool for easy screening. Toolbox T1. Toxicological tool for easy screening. Toolbox E1. Ecology tool for easy screening. Toolbox C2. Chemical tools for refined screening. Toolbox T2. Toxicological tool for refined screening. Toolbox E2. Ecology tool for refined screening. Toolbox C3. for detailed assessment. Toolbox T3. Toxicological tools for Assessment. Toolbox E3. Ecology tool for detailed assessment. Toolbox IV. Different tools for the final (Tier 4) assessments. Toolkit C1 — Simple Screening Chemistry ToolsFor the very first step in the ERA process, total concentrations of all relevant chemicals are individually compared to soil screening (SSL) levels to evaluate the need for a site-specific ecological risk assessment. In the current Stage III of the era, this first generic evaluation of risk is followed by a more site-specific screening of risk including information from all three lines of evidence in the Triad. In The Chemistry part of the Triad more scene-closer specific information is collected by:Refining and directing the comparison of soil concentrations with soil site-closer specific related benchmark purposes. incorporation of the cumulative risk of a mixture of impurities by calculating the toxic pressure (TP) of a mixture and by making it generate more site-specific insight into the potential ecological impact of a contaminated site; Each of these steps can be done separately or in combination, e.g. that TP can be calculated using existing SSL or using newly developed benchmarks based on either NOEC or EC50 values or that site-specific benchmarks can be compared with soil concentrations individually. The approach depends entirely on the strategy taken by the stakeholder group and the availability of data. Toolkit T1 — Toxicological tools for simple screeningThe main objective of the selected toxicity tests or bioassay at Tier 1 should be to screen the soil for the presence of toxic compounds. This includes toxic degradation products or compounds, which are not routinely included in various national pollution analysis programmes. This level is the first level of screening of the European and European systems and the cost in terms of labour and money should therefore be low. Equipment for measuring luminescence of Vibrio fischeri [94]Toolbox E1 — Ecology tools for simple screeningEcological examinations or monitoring studies are generally considered a time-consuming effort by experts. This is in most cases true, which is why detailed investigations typically take place in higher level assessment. However, in order to ensure that ecological information is also collected and used in the Triad already in the screening phase, it is recommended that a limited examination of the site be carried out. An examination of the site with a particular focus on visible changes in, for example, plant cover or the presence or absence of specific plants, trees or scrubs may indicate ecological damage, which may be associated with contaminants present on the site. Simple site survey [95]If aerial images are available from the area these can provide valuable information about the facility cover as well which can be helpful in identifying parts of the area where the effects may be highest (hot spots). At this stage in most cases can only be indicative. Therefore, if the results of the second line of evidence may cause any doubt or the investigation indicated potential impact, it is recommended to either proceed with a more refined screening in Tier 2 or go directly to the detailed assessment in Tier 3.Toolbox C2 — Chemistry tools for refined screeningSelective solvent extractionIt can be considered useful to adjust the estimation of exposure by taking bioavailability into account and deviating from conservatism normally associated with the use of total concentration in the risk assessment. The principle of this refinement of the ecological risk assessment is to extract a more ecotoxicologically relevant fraction of the contamination than the total concentration. The latter generally tends to overestimate the risk of historically contaminated soils. In this screening phase, no attempt is made to estimate the freely dissolved or readily bioavailable concentration of pollutants. Table 10 explains the main studies that used chemical extractive agents to evaluate bioavailability. Disposition of main studies that employed chemical extractants to evaluate bioavailability Instead the fraction of the impurities is extracted, which can be directly compared to the existing soil screening levels. This is considered a relatively simple and quick method of screening for potential risk of contamination in a more realistic way than using total concentrations. The extracted concentration (mg kg-1) is compared with SSL and the result used in the Triad. It is therefore a prerequisite for this comparison that the extractability of the tests (with impaled soils) used to derive SSL is close to 100% of the methods used. In most short-term tests (< four weeks) it will be reasonable to assume that only a little true aging or strong digestion occurs and thus a majority of the spiked chemicals are still extractable with mild organic solvents. For most methods, however, this must still be fully validated. The most commonly used organic solvents include methanol/water in different conditions, nbutanol, ethanol, propane pol, ethyl acetate and tetrahydrofurane (THF) given in Table 10. The method establishes the preferential division of hydrophobic pollutants into the extractor by increasing their solubility in the aqueous phase while removing pollutant compounds from soil surfaces that determine equilibrium conditions. No standard protocol has been adopted for mild chemical extractions in relation to bioavailability testing. Common methodology in the literature includes primarily a soil sample to which a volume of chemical extrafinement is added (generally 1 - 10 g of soil, 15 – 25 ml of extra suction fluid). This is followed by a mixing period, e.g. excessive mixing for 10 - 120 shaking of orbital shaking for up to 2 hours. The extraction studies have mostly involved PAH and and (including DDT, DDE, DDD and atrazine) [93-95]. Studies that have extractability with results from bioassays have generally focused on uptake and accumulation (% absorbed by earthworms or plants) and bacterial degradation (%removed). Therefore, since convincing relationships between the chemical and biological tests were found it may indicate a potential for such extraction methods to predict bioavailability. Toolkit T2 — Toxicological tools for refined screeningIn the first simple screening of Tier I focus was on marine bacteria and aquatic/sediment living species. Tier 2 uses relatively simple tests with terrestrial species for a more refined screening of soil samples, i.e. the soil samples. The Eisenia fetida avoidance test is an appropriate screening test, which is less costly in terms of duration and workload than the reproductive test, and at the same time (normally) more sensitive than the acute test of the same species. Toolkit E2 — Early refinement ecology tool In Tier 2, observations from the study can be extended by simple on-site assessment of the total function or biological activity of the soil. Recommended tools include bait-lamina sticks and simple microbial tests using general endpoints like soil breathing or C/N mineralization rates. Bait-lamina sticks [99]The main principle of testing at this level is to be relatively simple and inexpensive while providing valuable information whether the earth has lost some of its main services or not. Bait-lamina sticks for example have proven useful in describing biological activity of the soils in a general matter. Toolbox C3 — Chemistry tools for detailed assessmentThe purpose of the tools contained in this toolbox is to assess the bioavailable and freely dissolved fraction of pollutants present in pore water of soils from contaminated areas. The methods should (in principle) be able to mimic the fraction of organic pollutants present for uptake in biota. Collection of methods includes various non-depletion and depletion pore water extractions. Very few terrestrial ecotoxicity data are yet expressed as e.g. pore water concentrations. Instead, the outcome of the methodology in this toolbox is compared with water quality standards. Toolbox T3 — Toxicological tools for detailed assessmentThe purpose of the tools contained in this toolbox is to evaluate the potential impact of contaminated soils on fauna and plants and hereby the entire ecosystems. Some of the methods used are introduced, and not inherent, species. The advantage of this is a higher degree of standardization, as the species used in these bioassays are easy to maintain in the laboratory compared to naturally occurring species. The downside may be that their ecological relevance is less obvious. For example, the compost worm Eisenia fetida is used as a surrogate to evaluate the risk of grounding home worms. Two sets of bioassays are presented. One to directly assess the potential risk to terrestrial species, including micro-organisms, plants and invertebrates, and one to assess indirect risk to aquatic species through, for example, the risk to aquatic species through, for example, the risk to aquatic species, the risk to the environment, the It is often expected that soil organisms are exposed to pollution mainly through uptake from pore water. Therefore, it may also be possible to evaluate, or at least to compare or rank, the risk of contaminated soil samples to terrestrial organisms on the basis of the outcome of the water test with elutriated water or pore water. The choice of bioassays depends on a number of variables, such as the :D current and future land use, i.e. the use of land use, The size of the contaminated area. the potential for soil water or surface water pollution; The need for many simple tests or fewer more complicated tests. Simple Plant Tests [91]Toolbox E3 - Ecology tools for detailed assessmentIn this late level of the Triad, the goal of the activities is community or population response analysis, typically by conducting field surveys. Since these studies are (usually) time-consuming, costly and dependent on ecological, taxonomic and statistical expertise, they are usually done in large-scale locations with a long-term clean-up perspective. In the freshwater ecosystem community surveys have been widely used with relative success. The absence of species from places where they would occur could be a strong identification of unacceptable levels of pollution. However, this type of study has only rarely been used for the terrestrial environment. The reasons for this are many. One of the dominant ones may be the absence of a concentration gradient and obvious upstream reference areas in most contaminated areas. No worldwide accepted guideline on how to plan and perform a terrestrial field survey is available and thus no straightforward and easy to follow description can be given. The decision on when, where and how to carry out field surveys depends on a number of issues, such as the size of the area, land use, the type of pollution, the time of year and last but not least the time and money available to carry out the study. Nevertheless, a number of general considerations need to be made in the planning phase of a successful field survey. These include (but are not limited to):Identify targets for concern and the species to be monitored. Highlight the natural temporal and spatial variation before you begin a field study. Use statistical (power) analyses to determine the minimum number of samples or replicates needed to emonstrate the difference decided; 25% change. In order to establish a causal link, a number of confusion parameters need to be characterised at both the reference and test site, e.g. soil type, pH, salinity, hydrology, nutrient and organic matter content and the presence of other impurities. Since no single description of how ecological surveys for contaminated sites can be carried out, some general considerations and useful references for this level are given the ecological risk assessment for:Assessing the impact in overall biological activity and the degradation of organic matter. Assessment of the impact on the microbial society. Assessment of the impact on the plant society. Assessment of the effects on invertebrate society. Reference data from reference sites, samples and literatureA decisive factor in a risk assessment is the quality of the reference data, as the results of the site-specific ecological measurements or calculations are compared against this data. This applies to chemical information (i.e. background levels in that region), toxicological data from bioassays (i.e. site-relevant reference soil and well-characterized control soil to verify test performance) and ecological field studies. Bedding bags [94]The reference soil should in principle resemble the contaminated soil in all relevant parameters, e.g. In practice, these ideal places are difficult to find. If there is no or insufficient reference information, effects can only be determined in relative terms compared to other websites. This is usually adequate to determine the degree of urgency and/or the need for remediation. Reference data can be obtained by including reference sites (preferably more than one) in the sampling scheme, including reference measurements in the experimental order, or by obtaining reference data from the literature or through expert-based judgement. Higher level assessment of the impact on biological activity and degradation of organic matterIn addition to the general information on biological activity in soils generated in Tier 2 from the test bait lamina, other, slightly more arduous, tests can provide additional information on the overall biological activity of soil, e.g. wheat straw degradation (garbage bag test) and cotton band degradation. A review paper from Van Gestel et al. (2003) concluded that while bait-lamina gave the best reflection of the biological activity of soil animals, such as earthworms, springtails and enchytraeids, the litter bag test and cotton strip test are more indicative of the microbial activity in the soil [96]. Knacker et al. (2003) examined the benefits of five different litter decompositions and concluded that the litter bag test had clear advantages over the others [97]. All these simple tests only provide insight into the overall soils and organic matter degradation. They are thus most appropriate on their own in cases of low sensitivity land use, e.g. in the case of low sensitivity. For land use where structural endpoints, e.g. land use, are used to use land use. Higher level assessment of the impact on the microbial communityThe number of microorganisms, especially bacteria, in soil is extremely large. They differ greatly in their function and sensitivity to chemicals. In addition to more classical (and simple) measures by the microbial community such as total bacterial biomass, the number of colony-forming units and substance induced respiratory velocity (SIR), more advanced methods for assessing the impact of pollution on soil microorganisms have recently been made available. Microbial Society [96]This includes microbial fingerprints such as phospholipid fatty acid analysis (PLFA) and community-level physiological-profiling (CLPP) based on metabolic response using biologist plate systems, and the use of impurities induced community tolerance (PICT). Higher level assessment of the impact on the plant societyPlants interact dynamically with the physical and chemical properties of the soil. Soil types and site characteristics, therefore greatly affect the presence of plants and their total above-ground biomass (also called, Net Primary Production, i.e. NPP) within given climatic conditions and human management. Vegetation cover is an important indicator of soil quality and a diverse plant society is normally a good indication of essential soil functions such as the decomposition process, the degree of mineralisation, and the presence of terrestrial habits associated with (fresh) organic matter. Vascular plants are easy to sample. They are immobile and associated with soil pollution (and airborne pollution). Plant Community parameters such as plant cover, above-ground plant biomass, plant shoots/root ratios, species diversity and the binary occurrence (presence/absence) of specific indicator species such as metal-tolerant species may be used successfully in ERA. Plant survey [95]Higher level assessment of impact on soil invertebrate communityRetarable soil biota to evaluate the impact of various sources of pollution on soil communities on historically contaminated sites has not yet been used on a larger scale by e.g. However, many (monitoring) studies by different research groups can be found in the open literature. Methods of surveying include:Collection of soil samples followed by extraction in the laboratory. extraction or collection of organisms in fields, e.g. by hand sorting or by application of mustard or formalin; Trapping (surface-living) animals by using e.g. Monitoring species include earthworms, snails, oribatid mites, nematodes, ants, ground-living beetles and spiders. Most of the studies have been done on metal contaminated sites (see references below). A significant amount of work has been put into the challenge of developing a system of invertebrate soils to evaluate the risk of pollution. The only invertebrate soil system used regularly in the context of ecological risk assessment of contaminated soils is by far the largest nematode matured index (MI). The system is based on the evidence that fast colonizing species dominate nematode communities in disturbed ecosystems. In the Netherlands, experience of studies of earthless animals from the Biological Indicator for Soil Quality (BISQ) monitoring programme has also been used in ERA.. Soil Fauna Sampling [98]Tier IV Test Toolbox The final assessment in the ERA process is unlikely to start for many contaminated sites. The choice of additional tests or monitoring at this level of the European and European area is bound to be very site-specific and therefore a matter for negotiations between stakeholders and experts. Accumulation in biota is included in this toolbox as the internal concentration in biota is believed, at least to some extend, to reflect uptake and then bioavailability. One option at this final level could also be to model uptake in biota that is provided with sufficient data available [98]. Detailed field investigation [93]The aim is to investigate whether the soil has been contaminated, and whether contamination has occurred if the contamination poses a significant risk of injury. The international practice usually found consists of three distinct reporting phases. It progresses from phase 1 assessments of stationary and site walks with limited examination and testing to a detailed invasive investigation and testing of phase 2 for characterisation of the site to a comprehensive Phase 3 report with an evaluation of clean-up targets and a proposed decontamination plan, supported by control and monitoring measures for the operation. A phased approach to the assessment and remediation of contaminated soil reporting system requires strict application of standards and standards of practice, but must also retain flexibility to allow contaminated status decisions for sites to be made in the most advantageous way (taking into account ecological, social and economic aspects) also taking into account timeframes. In some cases, urgent priority work may require that the step-by-step approach to reporting must be made forward in a simultaneous single report. A preliminary site assessment must take into account the following elementsThe description mode and size nature of the site and the extent of contamination, contamination of concerns and historical activities that may be sources of contamination. List all current and past activities on the site that involve storage and production, treatment or disposal of hazardous materials that may contaminate contaminating current state of the site and the content and results of any previous assessment reportLocal topography and geology, drainage, surface cover, vegetation. Status of groundwater, approximate depth to groundwater levelProximity to surface waterProximity to drinking water supplyAnnual rainfall and flood potentialCountry and water use for the nearby areas and areaNo other regulations regulated by the MinistryAll data may not be available, or data may vary in terms of uncertainty, it is thus important to recognize gaps in the knowledge base and to decide whether additional data need to be obtained on the area of characterization. This may trigger the initiation of Phase 2 investigations. The Phase 1 report must make clear recommendations on the status of the contamination risk posed by the site. If a full location history clearly shows that the site's activities do not constitute a threat of contamination, no further investigation is warranted and the site should be recommended as suitable for reuse. In most cases, it is likely that a certain level of preliminary investigation will be required to provide the level of security necessary to enable the development or transfer of property. A limited examination of certain activities below the surface, such as underground storage tanks, would be necessary to obtain an exemption on the pollution status of a site at a Phase 1 level of reporting. Where soil pollution is found at concentrations exceeding the applicable standards specified in the approval, the holder of the approval is required to implement a land management programme. The program must first address source control to stop ongoing pollution emissions. After the sources of contamination have been stopped, further assessment and delineation of the contaminated site may be necessary. When the extent of contamination is understood, the remediation targets described below must be adopted for the site. Once the clean-up targets have been agreed, appropriate treatment or containment techniques can be chosen and the management plan completed. Clean-up targets can be developed in a variety of ways, from generic guidelines to site-specific risk assessment. Generic guidelines are numerical concentration limits applicable under a variety of area conditions. When neither Environmental Protection nor the Agency has a guideline for a particular substance, there are four options. Firstly, the decontamination target can be based on the ambient background concentration of the site. Secondly, the development protocol for the guideline can be applied. Thirdly, a remediation case may be adopted from another jurisdiction if the advocate can demonstrate that the remediation objective is compatible with the environmental protection objectives of the approval. Finally, a clean-up target may be developed by the advocate using site-specific risk assessment A risk assessment for an approved plant will focus on people's health problems, but fundamental ecological problems must also be addressed. Site-specific risk assessment is a way of quantifying the likelihood that soil contamination will have an adverse effect under conditions found at a specific location. The essential elements of human health and ecological risk assessments are similar; However, ecological risk assessments tend to be more complex than those for human health as a large variety of receptors may need to be considered. Very briefly, a site-specific risk assessment can be described as consisting of the following steps or components as shown in Figure 20; Problem formulation involves developing a conceptual model of the possible pollution effects on receptors on the site. The conceptual model describes the distribution and concentration of pollution in relation to the receptors and their activity patterns on the site. The exposure assessment describes the pathways by which soil contamination can be absorbed by the receptor. This information is combined with receptor properties in order to estimate contamination uptake. The toxicity assessment describes the adverse effects that the pollutants may cause and the dose at which these effects occur. Risk assessment frameworkThe last step, risk characterisation, compares this dose with the uptake rate (estimated during the exposure assessment) and determines whether or not a negative effect is likely to occur. Risk assessment procedures can also be used to reverse calculate a soil pollution concentration at which no adverse effects are expected. Sometimes it may not be possible to address a level that is consistent with industrial land use objectives. In such cases, the holder of the authorisation must ensure that the impurities are contained and that receptor exposure does not occur. Formal risk assessment procedures are necessary to meet these requirements. Usually a constructed containment system is required, the performance of which must be confirmed by periodic inspections and monitoring. The holder of the approval is responsible for the design, design, assessment and maintenance of the risk management system, and all necessary emergency measures in the event of failure. Enforcement is generally the final step in a regulatory process aimed at first preventing potential problems before they arise and solving existing problems in a cooperative manner. When discussions between the consent holder and the department do not prevent or resolve a violation of an approval or the law, a number of tools for purification and enforcement are available to the department, including:environmental protection decisions;warning letters;tickets;administrative penalties;enforcement orders;prosecution;court order; and attacks of approvals or certificates. Due to various factors, including the high high participating in clean-up efforts, it is important that a holistic and differentiated, risk-based approach based on international best practice is adopted, in order to manage clean-up in a uniform manner across the country. This is relevant regardless of the sector that exists to protect both human health and the natural environment. The framework is based on a review of international practices in developed countries around the world and the emergence of remediation policies from developing countries, and an assessment of alternative approaches and methods that may be applied in the development of a clean-up framework. Soil pollution is the result of many activities and experiments done by humanity that ultimately pollute the soil. Industrial waste such as harmful gases and chemicals, agricultural pesticides, fertilizers and insecticides are the most common causes of soil contamination. The others are ignorance of land management and related systems, unfavorable and harmful irrigation methods, improper septic system and management and maintenance of the same, leakage from sanitary wastewater. There is an urgent need for a differentiated approach to the ecological risk assessment of contaminated soils. Generic land screening levels are needed as a first level. However, higher levels of ecological risk assessment should include some form of site-specific assessment. Furthermore, it is important to organise the various studies in a framework or decision support system that is transparent and useful to all stakeholders. A weight of evidence approach can be an obvious choice to deal with these uncertainties. The Triad method, which incorporates and categorises information into a triangle – chemistry, toxicology and ecology – is an appropriate tool for managing conceptual uncertainties. Several remedies to these shortcomings have been proposed. In the case of ecotoxicity direct testing would allow for a major improvement in risk estimates. Regarding human health issues: including biological availability in risk estimates, more use of accurate knowledge of routes of exposure, dose-effect relationships and combination effects, and biomonitoring of effects are improvement options. 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