ISSN: 2395-7639

International Journal of Multidisciplinary Research in Science, Engineering, Technology & Management (IJMRSETM)

Visit: www.ijmrsetm.com

Volume 1, Issue 1, October 2014

A Critical Review on Ecotoxicology, Environmental Safety and Possible Remediation

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ABSTRACT: Ecotoxicology is the study of the effects of toxic chemicals on biological organisms, especially at the population, community, ecosystem, and biosphere levels. Ecotoxicology is a multidisciplinary field, which integrates toxicology and ecology.

The ultimate goal of ecotoxicology is to reveal and predict the effects of pollution within the context of all other environmental factors. Based on this knowledge the most efficient and effective action to prevent or remediate any detrimental effect can be identified. In those ecosystems that are already affected by pollution, ecotoxicological studies can inform the choice of action to restore ecosystem services, structures, and functions efficiently and effectively. Environment (E), health (H) and safety (S), EHS is an acronym for the set that studies and implements the practical aspects of protecting the environment and maintaining health and safety at occupation. In simple terms it is what organizations must do to make sure that their activities do not cause harm to anyone. Commonly, quality - quality assurance and quality control - is adjoined to form the company division known as HSQE.

From a safety standpoint, it involves creating organized efforts and procedures for identifying workplace hazards and reducing accidents and exposure to harmful situations and substances. It also includes training of personnel in accident prevention, accident response, emergency preparedness, and use of protective clothing and equipment.

Better health at its heart, should have the development of safe, high quality, and environmentally friendly processes, working practices and systemic activities that prevent or reduce the risk of harm to people in general, operators, or patients. Environmental remediation deals with the removal of pollution or contaminants from environmental media such as soil, groundwater, sediment, or surface water. Remedial action is generally subject to an array of regulatory requirements, and may also be based on assessments of human health and ecological risks where no legislative standards exist, or where standards are advisory

KEYWORDS: ecotoxicology, environmental safety, remediation, pollution, hazards, patients, health

I. INTRODUCTION

Ecotoxicology is a relatively young discipline that made its debuts in the 1970s[2] in the realm of the environmental sciences. Its methodological aspects, derived from toxicology, are widened to encompass the human environmental field and the biosphere at large. While conventional toxicology limits its investigations to the cellular, molecular and organismal scales, ecotoxicology strives to assess the impact of chemical, physicochemical and biological stressors, on populations and communities exhibiting the impacts on entire ecosystems. In this respect, ecotoxicology again takes into consideration dynamic balance under strain.[1,2]

Ecotoxicology emerged after pollution events that occurred after World War II heightened awareness on the impact of toxic chemical and wastewater discharges towards humankind and the environment. The term "Ecotoxicology" was uttered for the first time in 1969 by René Truhaut, a toxicologist, during an environmental conference in Stockholm. As a result, he was de facto recognized as the originator of this discipline. In fact, the pioneering role of Jean-Michel Jouany, Truhaut's assistant, in conceptualising the discipline[3] and in defining its objectives,[4] is now fully recognized. In Jouany's mindset, ecotoxicology is primarily linked to ecology for its goal seeks to circumscribe the influence that stress factors can have on relationships existing between organisms and their habitat. Jean-Michel Jouany was indeed the young and brilliant mentor of René Truhaut who was at the time empowered to disseminate the emerging discipline proposed by his young assistant at the international level. Jean-Michel Jouany was promoted to the rank of full

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professor at the University of Nancy in 1969. He then laid out the teaching and research principles for ecotoxicology at the University of Metz with his colleague, Jean-Marie Pelt, as early as 1971.[5]

In France, two universities (Metz and Paris-Sud) markedly contributed to expand this burgeoning discipline during the 1980s and 1990s. Several institutes followed suit in this respect. Indeed, CEMAGREF (now IRSTEA), INERIS, IFREMER and CNRS created research units in ecotoxicology, as did other French universities (in Rouen, Bordeaux, Le Havre, Lyon, Lille, Caen...).[6] During the 1990s, a new offshoot of ecotoxicology casually appears known as Landscape ecotoxicology, whose objective seeks to take into account interactions between landscape ecological processes and environmental toxicants, in particular for species undergoing impediments linked to migratory passageways* (e.g., salmonids).

The chemical industry introduced the first formal EHS management approach in 1985 as a reaction to several catastrophic accidents (like the Seveso disaster of July 1976 and the Bhopal disaster of December 1984). This worldwide voluntary initiative, called "Responsible Care", started by the Chemistry Industry Association of Canada (formerly the Canadian Chemical Producers' Association - CCPA), operates in about 50 countries, with central coordination provided by the International Council of Chemical Associations (ICCA). It involves eight fundamental features which ensure plant and product safety, occupational health and environmental protection, but which also try to demonstrate by image-building campaigns that the chemical industry acts in a responsible manner. Being an initiative of the ICCA, it is restricted to the chemical industry.[3,4]

Since the 1990s, general approaches to EHS management that may fit any type of organisation have appeared in international standards such as: The Valdez Principles,[7] that have been formulated to guide and evaluate corporate conduct towards the environment.

- the Eco-Management and Audit Scheme (EMAS), developed by the European Commission in 1993
- ISO 14001 for environmental management in 1996
- ISO 45001 for occupational health and safety management in 2008, preceded by OHSAS 18001 1999

In 1998 the International Finance Corporation established EHS guidelines.

In the United States, the most comprehensive set of Preliminary Remediation Goals (PRGs) is from the Environmental Protection Agency (EPA) Regional Screening Levels (RSLs).[2] A set of standards used in Europe exists and is often called the Dutch standards. The European Union (EU) is rapidly moving towards Europe-wide standards, although most of the industrialised nations in Europe have their own standards at present. In Canada, most standards for remediation are set by the provinces individually, but the Canadian Council of Ministers of the Environment provides guidance at a federal level in the form of the Canadian Environmental Quality Guidelines and the Canada-Wide Standards|Canada-Wide Standard for Petroleum Hydrocarbons in Soil.[3]

Once[4] a site is suspected of being contaminated there is a need to assess the contamination. Often the assessment begins with preparation of a Phase I Environmental Site Assessment.[5] The historical use of the site and the materials used and produced on site will guide the assessment strategy and type of sampling and chemical analysis to be done. Often nearby sites owned by the same company or which are nearby and have been reclaimed, levelled or filled are also contaminated even where the current land use seems innocuous. For example, a car park may have been levelled by using contaminated waste in the fill. Also important is to consider off site contamination of nearby sites often through decades of emissions to soil, groundwater, and air. Ceiling dust, topsoil, surface and groundwater of nearby properties should also be tested, both before and after any remediation.[5,6] This is a controversial step as:

1. No one wants to have to pay for the cleanup of the site;
2. If nearby properties are found to be contaminated it may have to be noted on their property title, potentially affecting the value;
3. No one wants to pay for the cost of assessment.

Often corporations which do voluntary testing of their sites are protected from the reports to environmental agencies becoming public under Freedom of Information Acts, however a "Freedom of Information" inquiry will often produce other documents that are not protected or will produce references to the reports[7,8]

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II. DISCUSSION

Chemicals are shown to prohibit the growth of seed germination of an arrangement of different plant species. Plants are what make up the most vital trophic level of the biomass pyramids, known as the primary producers. Because they are at the bottom of the pyramid, every other organism in an ecosystem relies on the health and abundance of the primary producers in order to survive.[9,10] If plants are battling problems with diseases relating to exposure to chemicals, other organisms will either die because of starvation or obtain the disease by eating the plants or animals already infected. So ecotoxicology is an ongoing battle that stems from many sources and can affect everything and everyone in an ecosystem [15]

Regulation:

- In the United States, the Environmental Protection Agency (EPA) reviews all pesticides before the products are registered for sale to ensure that the benefits will outweigh the risks.
- Food Quality Protection Act and the Safe Drinking Water Act were passed in 1996, which required EPA to screen pesticide chemical for potential to produce harmful effects.
- Keep close track of the labeling when using a fertilizer, or pesticide. Try to look for products that will have less of an impact on the environment [16]
- There are many federal and state laws protecting birds, animals, and rare plants. But the first order of protection comes from us taking steps to avoid harm since we are the main source of all the toxins.
- Proper waste disposal[11,12]

Remediation technologies are many and varied but can generally be categorized into ex-situ and in-situ methods. Ex-situ methods involve excavation of affected soils and subsequent treatment at the surface as well as extraction of contaminated groundwater and treatment at the surface. In-situ methods seek to treat the contamination without removing the soils or groundwater. Various technologies have been developed for remediation of oil-contaminated soil/sediments.[6][7]

Traditional remediation approaches consist of soil excavation and disposal to landfill and groundwater "pump and treat". In-situ technologies include but are not limited to: solidification and stabilization, soil vapor extraction, permeable reactive barriers, monitored natural attenuation, bioremediation-phytoremediation, chemical oxidation, steam-enhanced extraction and in situ thermal desorption and have been used extensively in the USA.[8]

Using nano-sized reactive agents to degrade or immobilize contaminants is termed nanoremediation. In soil or groundwater nanoremediation, nanoparticles are brought into contact with the contaminant through either in situ injection or a pump-and-treat process. The nanomaterials then degrade organic contaminants through redox reactions or adsorb to and immobilize metals such as lead or arsenic. In commercial settings, this technology has been dominantly applied to groundwater remediation, with research into wastewater treatment.[13] Research is also investigating how nanoparticles may be applied to cleanup of soil and gases.[14]

Nanomaterials are highly reactive because of their high surface area per unit mass, and due to this reactivity nanomaterials may react with target contaminants at a faster rate than would larger particles. Most field applications of nanoremediation have used nano zero-valent iron (nZVI), which may be emulsified or mixed with another metal to enhance dispersion.[15][16]

That nanoparticles are highly reactive can mean that they rapidly clump together or react with soil particles or other material in the environment, limiting their dispersal to target contaminants.[17] Some of the important challenges currently limiting nanoremediation technologies include identifying coatings or other formulations that increase dispersal of the nanoparticle agents to better reach target contaminants while limiting any potential toxicity to bioremediation agents, wildlife, or people[17,18]

Bioremediation is a process that treats a polluted area either by altering environmental conditions to stimulate growth of microorganisms or through natural microorganism activity, resulting in the degradation of the target pollutants. Broad categories of bioremediation include biostimulation, bioaugmentation, and natural recovery (natural attenuation). Bioremediation is either done on the contaminated site (in situ) or after the removal of contaminated soils at another more controlled site (ex situ).

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In the past, it has been difficult to turn to bioremediation as an implemented policy solution, as lack of adequate production of remediating microbes led to little options for implementation. Those that manufacture microbes for bioremediation must be approved by the EPA; however, the EPA traditionally has been more cautious about negative externalities that may or may not arise from the introduction of these species. One of their concerns is that the toxic chemicals would lead to the microbe's gene degradation, which would then be passed on to other harmful bacteria, creating more issues, if the pathogens evolve the ability to feed off of pollutants.[19,20]

III. RESULTS

Ecotoxicity testing

- Acute and chronic toxicity tests are performed terrestrial and aquatic organisms including fish, invertebrates, avians, mammalians, non-target arthropods, earthworms and rodents.
- The Organization for Economic Cooperation and Development (OECD) test guideline has developed specific tests to test toxicity level in organisms. Ecotoxicological studies are generally performed in compliance with international guidelines, including EPA, OECD, EPPO, OPPTTS, SETAC, IOBC, and JMAFF.
- LC50 is the acute toxicity, the lethal concentration at which 50% of the test organism dies within the test-specified time. The test may start with eggs, embryos, or juveniles and last from 24 hours to 96 hours
- EC50 is the concentration that causes adverse effects in 50% of the test organisms (for a binary yes/no effect such as mortality or a specified sublethal effect) or causes a 50% (usually) reduction in a non-binary parameter such as growth.
- No observed effect concentration (NOEC) is the highest dose of stressor at which there is no statistically significant difference of effect ($p<0.05$) seen in the test organism.
- Endocrine Disruptor Screening Program (EDSP)
- Tier 1 screening battery
- Endangered species assessments.
- Persistent, Bioaccumulative, and Inherently Toxic (PBiT) assessments using the Quantitative Structure-Activity Relationships (QSARs) to categorize regulated substances.
- Bioaccumulation in fish using the Bioconcentration Factor (BCF) methods.[17]

Environmental health was defined in a 1989 document by the World Health Organization (WHO) as: Those aspects of human health and disease that are determined by factors in the environment. It is also referred to as the theory and practice of accessing and controlling factors in the environment that can potentially affect health.

A 1990 WHO document states that environmental health, as used by the WHO Regional Office for Europe, "includes both the direct pathological effects of chemicals, radiation and some biological agents, and the effects (often indirect) on health and well being of the broad physical, psychological, social and cultural environment, which includes housing, urban development, land use and transport."[2]

As of 2010, the WHO website on environmental health states that "Environmental health addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviours. It encompasses the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments. This definition excludes behaviour not related to environment, as well as behaviour related to the social and cultural environment, as well as genetics."[3]

The WHO has also defined environmental health services as "those services which implement environmental health policies through monitoring and control activities. They also carry out that role by promoting the improvement of environmental parameters and by encouraging the use of environmentally friendly and healthy technologies and behaviors. They also have a leading role in developing and suggesting new policy areas."[4][5]

The term environmental medicine may be seen as a medical specialty, or branch of the broader field of environmental health.[6][7] Terminology is not fully established, and in many European countries they are used interchangeably.[8]

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Children's environmental health is the academic discipline that studies how environmental exposures in early life—chemical, nutritional, and social—influence health and development in childhood and across the entire human life span.[9]

Other terms referring to or concerning environmental health include environmental public health and health protection.

Environmental health addresses all human-health-related aspects of the natural environment and the built environment. Environmental health concerns include:

- Air quality, including both ambient outdoor air and indoor air quality, which also comprises concerns about environmental tobacco smoke.[21]
- Biosafety.
- Disaster preparedness and response.
- Climate change and its effects on health.
- Environmental racism, wherein certain groups of people can be put at higher risk for environmental hazards, such as air, soil, and water pollution. This often happens due to marginalization, economic and political processes, and ultimately, racism. Environmental racism disproportionately affects different groups globally, however generally the most marginalized groups of any given region/nation.
- Food safety, including in agriculture, transportation, food processing, wholesale and retail distribution and sale.
- Hazardous materials management, including hazardous waste management, contaminated site remediation, the prevention of leaks from underground storage tanks and the prevention of hazardous materials releases to the environment and responses to emergency situations resulting from such releases.
- Housing, including substandard housing abatement and the inspection of jails and prisons.
- Childhood lead poisoning prevention.
- Land use planning, including smart growth.
- Liquid waste disposal, including city waste water treatment plants and on-site waste water disposal systems, such as septic tank systems and chemical toilets.
- Medical waste management and disposal.
- Noise pollution control.
- Occupational health and industrial hygiene.
- Radiological health, including exposure to ionizing radiation from X-rays or radioactive isotopes.
- Recreational water illness prevention, including from swimming pools, spas and ocean and freshwater bathing places.
- Safe drinking water.
- Solid waste management, including landfills, recycling facilities, composting and solid waste transfer stations.
- Toxic chemical exposure whether in consumer products, housing, workplaces, air, water or soil.
- Vector control, including the control of mosquitoes, rodents, flies, cockroaches and other animals that may transmit pathogens.

According to recent estimates, about 5 to 10% of disability-adjusted life years (DALYs) lost are due to environmental causes in Europe. By far the most important factor is fine particulate matter pollution in urban air.[20] Similarly, environmental exposures have been estimated to contribute to 4.9 million (8.7%) deaths and 86 million (5.7%) DALYs globally.[21] In the United States, Superfund sites created by various companies have been found to be hazardous to human and environmental health in nearby communities. It was this perceived threat, raising the specter of miscarriages, mutations, birth defects, and cancers that most frightened the public.[22]

In preparation for any significant remediation there should be extensive community consultation. The proponent should both present information to and seek information from the community. The proponent needs to learn about "sensitive" (future) uses like childcare, schools, hospitals, and playgrounds as well as community concerns and interests information. Consultation should be open, on a group basis so that each member of the community is informed about issues they may not have individually thought about. An independent chairperson acceptable to both the proponent and

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the community should be engaged (at proponent expense if a fee is required). Minutes of meetings including questions asked and the answers to them and copies of presentations by the proponent should be available both on the internet and at a local library (even a school library) or community centre. The rezoning is often resisted by local communities and local government because of the adverse effects on the local amenity of the remediation and the new development. The main impacts during remediation are noise, dust, odour and incremental health risk. Then there is the noise, dust and traffic of developments. Then there is the impact on local traffic, schools, playing fields, and other public facilities of the often vastly increased local population[22]

IV. CONCLUSIONS

To protect the environment, the National Environmental Policy Act (NEPA) was written.[5] The main point that NEPA brings to light is that it "assures that all branches of government give proper consideration to the environment prior to undertaking any major federal actions that significantly affect the environment."[5] This law was passed in 1970 and also founded the Council on Environmental Quality (CEQ).[6] The importance of CEQ was that it helped further push policy areas.

CEQ created environmental programs including the Federal Water Pollution Control Act (RCRA), Toxic Substance Control Act, Resources Conservation and Recovery Act (RCRA and the Safe).[7] CEQ was essential in creating the foundation for most of the "current environmental legislation except for Superfund and asbestos control legislation."[6]

Some initial impacts of NEPA pertain to the interpretation within Courts. Not only did Courts interpret NEPA to expand over direct environmental impacts from any projects, specifically federal, but also indirect actions from federal projects.[6]

Environmental health professionals may be known as environmental health officers, public health inspectors, environmental health specialists or environmental health practitioners. Researchers and policy-makers also play important roles in how environmental health is practiced in the field. In many European countries, physicians and veterinarians are involved in environmental health. In the United Kingdom, practitioners must have a graduate degree in environmental health and be certified and registered with the Chartered Institute of Environmental Health or the Royal Environmental Health Institute of Scotland. In Canada, practitioners in environmental health are required to obtain an approved bachelor's degree in environmental health along with the national professional certificate, the Certificate in Public Health Inspection (Canada), CPHI(C). Many states in the United States also require that individuals have a bachelor's degree and professional licenses in order to practice environmental health. California state law defines the scope of practice of environmental health as follows:

"Scope of practice in environmental health" means the practice of environmental health by registered environmental health specialists in the public and private sector within the meaning of this article and includes, but is not limited to, organization, management, education, enforcement, consultation, and emergency response for the purpose of prevention of environmental health hazards and the promotion and protection of the public health and the environment in the following areas: food protection; housing; institutional environmental health; land use; community noise control; recreational swimming areas and waters; electromagnetic radiation control; solid, liquid, and hazardous materials management; underground storage tank control; onsite septic systems; vector control; drinking water quality; water sanitation; emergency preparedness; and milk and dairy sanitation pursuant to Section 33113 of the Food and Agricultural Code.

The environmental health profession had its modern-day roots in the sanitary and public health movement of the United Kingdom. This was epitomized by Sir Edwin Chadwick, who was instrumental in the repeal of the poor laws, and in 1884 was the founding president of the Association of Public Sanitary Inspectors, now called the Chartered Institute of Environmental Health[20]

Dioxins from Union Carbide used in the production of now-banned pesticide 2,4,5-Trichlorophenoxyacetic acid and defoliant Agent Orange polluted Homebush Bay. Remediation was completed in 2010, but fishing will continue to be banned for decades. An EU contract for immobilization of a polluted area of 20,000 m^3 in Bakar, Croatia based on solidification/stabilization with ImmoCem is currently in progress. After 3 years of intensive research by the Croatian government, the EU funded the immobilization project in Bakar. The area is contaminated with large amounts of TPH, PAH, and metals. For the immobilization, the contractor chose to use the mix-in-plant procedure.[22]

ISSN: 2395-7639

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