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Environment Risk Analysis and Mitigation for Plastic Pollution

ProSPER.Net Joint Research Project:
Recycling Plastics in Asian City Environments

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Case Summary

Currently, plastic products are extremely popular in many aspects of modern life. Plastic provides a durable, safe, and light material which is a better alternative to metal and other potentially toxic substances in many applications. However, the increasing demand and dependence of humanity on plastic items is generating a huge amount of plastic waste, and with this waste comes its own risk and toxic elements. In fact, many risks to human health and the environment can emerge from a plastic pollution, and reducing this threat requires reducing the use of plastic products in our day to day lives. The current state of plastic pollution and the threat it brings are alarming and require proper risk mitigation projects to tackle the challenge as soon as possible.

Learning Objectives

- To understand the risks generated from plastic pollution in cities;
- To understand the proper procedure in building a risk mitigation program;
- To learn how to build a framework of risk management and risk assessment related to plastic pollution.

Tips for Facilitators

The background information on the topic of plastic waste in Asian cities must be introduced first, with the issue frames as a threat to sustainable development which needs to be solved as soon as possible.

The threat from plastic pollution generates many risks, which can be classified into health risks and ecological risks. The background and definitions, theories of risk, and examples of health risks and ecological risks from plastic pollution in Asian cities should be introduced in Working Session 1.

The main objective of the curriculum must be centered on learning how to mitigate risk from plastic pollution. A framework for a plastic waste mitigation project should be created as a practical activity and learning outcome from the curriculum.

Working Session 1: Understanding about Plastic Pollution, Risk to Human Health, and Ecological Risk

Facilitation of the Learning Process

An environmental risk from plastic pollution is the potential of harm from plastic waste or the decomposition of plastic waste to air, soil, fresh water, marine environments, biodiversity, and/or human health and society. These risks can damage the economy, the health of people, or even destroy whole ecosystems, depending on the scale and level of risk, if left unchecked.

In the case of risk from plastic pollution, the risks can be broadly classified into either **health risks** or **ecological risks**.

Dealing with risk in general involves two tasks:

- *Identifying the degree/level of risk.*
- *Responding to the risk.*

Risks can also be classified as either:

- **Voluntary risks:** Usually the risks associated with activities that we decide to undertake, and can be assumed at an individual level.
- **Involuntary risks**: Usually the risks associated without human consent or knowledge, and are not the result of willful decision.

Environmental risks are often involuntary risks of exposure to a certain environmental hazard that people exposed to the risk had no agency in creating.

For example: The risk of plastic toxins from a landfill leaking into the ground water of a populated area adjacent to the landfill. In most instance, the local population did not choose the location of the landfill, but they are still impacted by it, meaning they are exposed to an involuntary risk.

Working Session 2. Building a Risk Mitigation Model through Risk Management

To mitigate risk from plastic pollution problems, a process including risk assessment and risk management must be established.

- Risk Assessment refers to identifiying the risks

A risk assessment project includes both qualitative and quantitative evaluations of risk from environmental hazards (in this case plastic waste) to human health and ecosystems.

- Risk Management refers to responding the risks

A risk management strategy requires many evaluation of the risk assessment and an appropriate selection from both regulatory and non-regulatory risk responses.

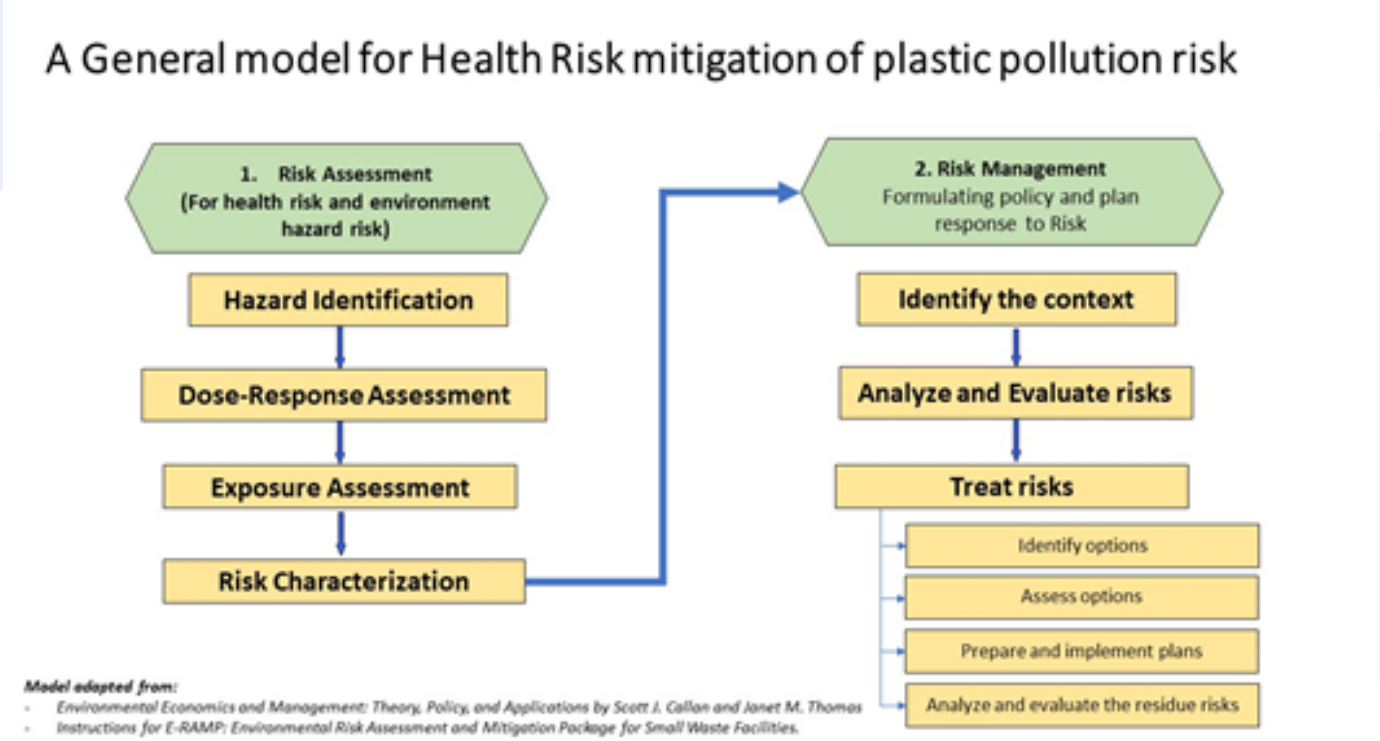

Fig 1: Model for Health Risk mitigation of plastic pollution risk.

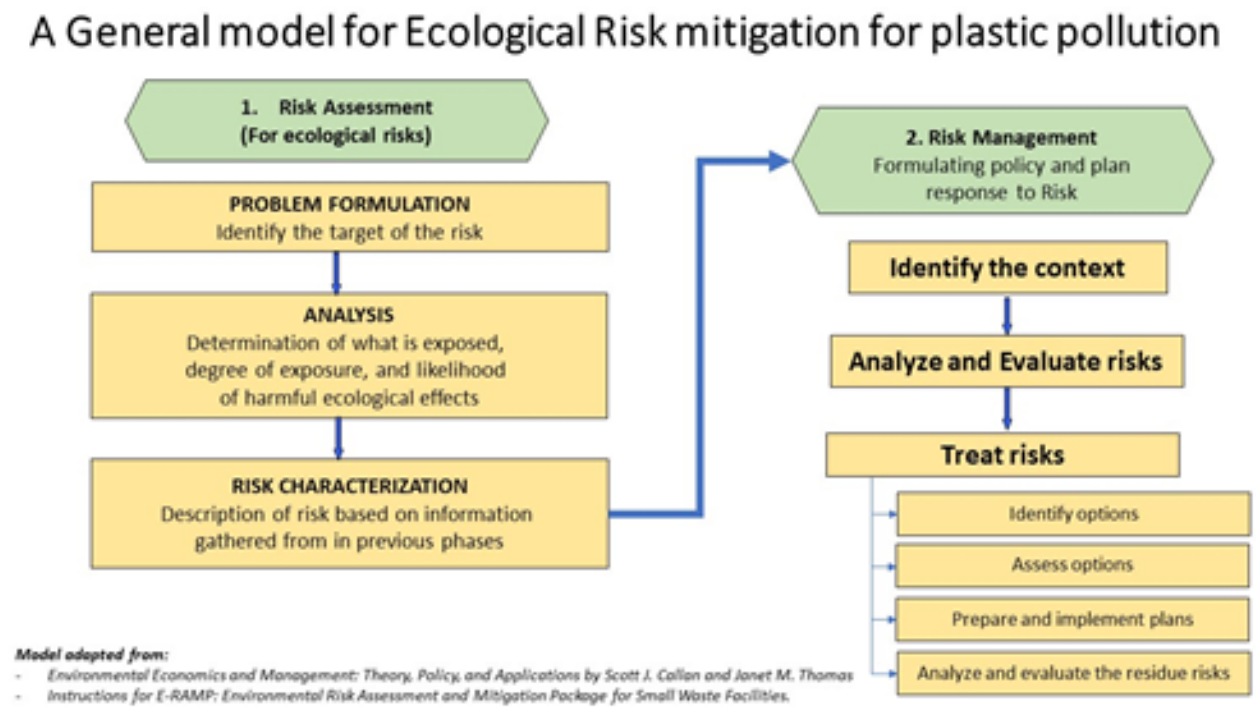

Fig. 2: Model for Ecological Risk mitigation for plastic pollution.

Risk assessment can be considered as an evaluation step for risk before any solution can be proposed. There are several steps in the risk assessment process, and these differ between health risk and ecological risk. For heath risks, the risk assessment steps usually includes hazard identification, dose-response assessment, exposure assessment, and risk characterization.

Hazard Identification

Hazard identification involves the use of scientific data to determine the *"causal"* relationship of the pollutant and adverse effects on health or ecosystems.

There are 3 scientific methods to identify health hazards:

- Case clusters: Some unusual or abnormal cases among a general population may identify a health hazard.
- Animal bioassay: Using scientific methods and experimental procedure on animals model in laboratory to analyze several risk factors causing health hazard.
- Epidemiology: The scientific study on the source and the distribution of diseases on a human population with many factors affect them.

Dose-Response Assessment

The dose-response assessment uses data from the hazard identification step to devise a profile of the pollutant's effects and gives a quantitative relationship between doses of the contaminant and corresponding reactions. The relationship of dose to response can be illustrated by a graph called a dose-response curve. There are two types of dose-response curves: one that describes graded responses of an individual to varying doses of a chemical, and one that describes the distribution of responses to different doses in a population of individuals. The dose is represented on the x-axis, while the response is represented on the y-axis.

Exposure Assessment

Exposure assessment is "the process of estimating or measuring the magnitude, frequency, and duration of exposure to an agent, along with the number and characteristics of the population exposed. Ideally, it describes the sources, routes, pathways, and uncertainty in the assessment. (See IPCS, 2004 Glossary of Key Exposure Assessment Terminology [1]). In exposure assessment, a generalized dose-response relationship is applied to specific conditions in order to estimate the potential of exposure on the population in response to a certain agent in the environment. The exposure assessment also characterizes the sources of an environmental hazard, concentration levels at which point the source becomes a hazard, pathways, and any sensitivities.

Risk Characterization

Risk characterization is the final phase of the health risk assessment process, and acts as a bridge between risk assessment and risk management. Risk characterization is defined as "... the process of estimating the incidence of a health effect under the various conditions of human exposure described in exposure assessment. It is performed by combining the exposure and dose-response assessments. The summary effects of the uncertainties in the preceding steps are described in this step." (U.S. Environmental Protection Agency EPA [2]).

Three Phases of Ecological Risk Assessment [3]

Problem Formulation

In the problem formulation phase of ecological risk management, the highest priority is to determining the important ecological entity at risk. Some examples of ecological entity can be:

- Organism species or functional group of species
- Community
- An ecosystem
- A habitat

When the ecological entity has been identified, the risk that affects the ecology entity must be identified next. This provides a basis for measurement in the risk assessment. When every factors of the problem formation step are identified, a conceptual model must be developed to provide a visual representation of relationships between ecological entities and the risk factors and causes affects them, together with a detailed description of this process and of the risk questions.

Analysis

The objective of the analysis phase is to provide the factors and context necessary for determining or predicting many ecological responses possible to stressors under exposure conditions of interest.

For example the analysis can be a determination of what organism in the area are exposed to what risk and the degree of exposure, together with possible harmful ecological effects.

Risk Characterization

The final step of Ecological Risk Assessment is to use the results of analysis to estimate the risk causing harms to ecological entities. The assessor then describes the risk, indicating the overall degree of confidence in the risk estimates, summarizing uncertainties, citing evidence supporting the risk estimates, and interpreting the adversity of ecological effects.

Working Session 3: Building Risk Mitigation Model: Risk Management

As described in the EPA's Risk Characterization Handbook, risk management is the process to evaluate how to protect public health. Risk management also evaluates and chooses from alternative responses to a certain environmental risks.

Examples of risk management actions for plastic pollution include deciding how dangerous toxic leachates from plastic in landfill discharge into water sources are; deciding which substances in plastic and at which levels in water bodies may destroy the ecosystem components; setting permit levels for landfills to stop burying plastics, etc.

Risk management strategies can be used to evaluate options in a systematic way. The risk manager must consider:

- The level of risk established
- The benefits to society from adopting the policy
- The associated costs of implementing the policy

Prevalent risk management strategies are:

- Comparative risk analysis

Known as risk-risk analysis when used to select from alternative policy instruments

- Risk-benefit analysis

Involves assessing the risks of a hazard along with the benefits to society of not regulating that hazard

- Benefit-cost analysis

Uses the economic criterion of allocative efficiency, comparing the Marginal social benefit (MSB) of a risk reduction policy to the associated Marginal social cost (MSC).

Each step of risk management in relation to plastic pollution must be discussed and an example should be given.

Working Session 4: Case Study: Building a Framework for a Risk Mitigation Project

Given the context of the current state of plastic pollution in one city, what is the best framework to solve each plastic pollution risk which could potentially damage the people and the ecology of the city? A whole framework with steps from both risk management and risk assessment phases should be built in detail, and a final constructed risk mitigation plan should be constructed after the working session.

References

1. World Health Organization (2004). IPCS Glossary of Key Exposure Assessment Terminology. ISBN 92 4 1562676 .
2. National Research Council (US) Committee on the Institutional Means for Assessment of Risks to Public Health. Risk Assessment in the Federal Government: Managing the Process. Washington (DC): National Academies Press (US); 1983. I, The Nature of Risk Assessment. Available from: https://www.ncbi.nlm.nih.gov/books/NBK216619/
3. U.S. Environmental Protection Agency EPA (2016). Conducting an Ecological Risk Assessment. Source: https://www.epa.gov/risk/conducting-ecological-risk-assessment#