A Brief Tutorial on the Application of Directed Acyclic Graphs (DAGS) for Environmental Risk Assessments (ERA) in the Nuclear Industry with an Illustrated Example

Contents

1. Environmental Risk Assessment (ERA)

An ERA of a nuclear facility is a systematic process used to identify, quantify, and characterize the environmental effects and risks resulting from exposure of human and biological receptors to contaminants and physical stressors released from the facility, throughout its lifecycle. The purpose is to ensure the safety, way of life and sustainability of human and biological receptors in the environment in which the facility is located.

The first step in the process is to identify

(a) relevant radiological and non-radiological contaminants and physical stressors (relevant stressors). These are referred to as Contaminants of Potential Concern (COPCs)

(b) relevant receptors,

(c) relevant exposure pathways,

(d) screening criteria (if available and applicable).

A screening is then carried out to identify contaminants and physical stressors that exceed pre-defined screening criteria, and are, therefore, of potential concern, and for which further remediation and/or or more detailed quantitative analysis would be warranted.

In the following sub-sections of this tutorial, we shall illustrate these concepts with an hypothetical albeit realistic example of a Human Health Risk Assessment (HHRA).

1.1. Relevant Stressors

1.1.1. Relevant Radiological Stressors

For the purposes of the example in this tutorial, we shall make the following assumptions with respect to Radiological emissions:

a. The radioactive sources used at the hypothetical Site are limited to the radionuclide's Co-60, Cs-137, and Radium-226.

b. We assume that, based on their hypothetical aggregate activities, only Co-60 and Cs-137 need be considered as relevant Contaminants of Potential Concern (COPC).

c. Radiological emissions from any source external to the Site are assumed to be insignificant.

d. Only cumulative radiation dose from both sources will be considered, and there are no external sources external to the site facility nearby.

e. The example will be limited to a Human Health Environmental Risk Assessment (HHRA); an Ecological Risk Assessment (EcoRA) of the exposure to contaminants and physical stressors released from the facility to flora and fauna will not be considered.

1.1.2. Relevant Non-Radiological Stressors

For the purposes of our tutorial example, we shall assume that there are no relevant non-radiological hazardous materials used at the site.

1.2. Relevant Receptors Selection

In this tutorial, a **Potential Critical Group (PCG)** will be defined as a group consisting of 1 or more individuals in the vicinity of the nuclear site facility (the Site), that share the same dietary and behavioral habits, and because of their proximity to the Site, may receive the highest exposure for a given radiological stressor and release pathway.

For the purposes of our tutorial example, we will assume that we have identified only one type of Potential Critical Groups (PCG) in the vicinity of the Site**,** which we consider to be in a remote urban community. The community is assumed to consist of 6,000 residents including industrial workers in 100 locations,

For the purposes of modeling potential exposure to radiological contaminants it is necessary to represent the members of each PCG with a Representative Person which reflects the shared characteristics common to each member of the PCG of which they are a representative, and so are characteristic of the members of the group as a whole.

It is also necessary to identify the Representative Person of a PCG with a location. This is taken to be the location of a member of the Representative Person's PCG that is "nearest" to the site, considering the prevailing wind direction, and other Site location specific factors), hence the most exposed to radiological contaminants. The RP provides a worst case, for comparative purposes to other members of the PCG.

For our tutorial example, the following hypothetical description and location of a single Representative Person corresponding to the

Potential Critical Group is assumed to be a Restaurant Employee (RP) located approximately 1 km northwest of the Site.

1.3. Selection of Relevant Exposure Pathways

In our example, the relevant exposure pathways for the cumulative radiological emissions from the Site will be assumed to consist of the following exposure pathways, and which we also assume are applicable to all members of the single Potential Critical Group:

Atmospheric deposition of radionuclides:

P1: Exposure from Direct Deposition onto Receptors

Directly onto Receptors who would be in danger from being externally exposed to radiation, and/or from inhalation/skin absorption.

Site -> Air -> Receptors

P2: Indirect Exposure to Contaminated soil

Receptors would be in danger from being externally exposed to radiation indirectly from contaminated soil

Site -> Air -> Soil -> Receptors

P3: Indirect Exposure from Ingestion of Contaminated Plant and Animal Products

Receptors would be in danger from being externally exposed to radiation indirectly from ingestion of contaminated plant and animal products.

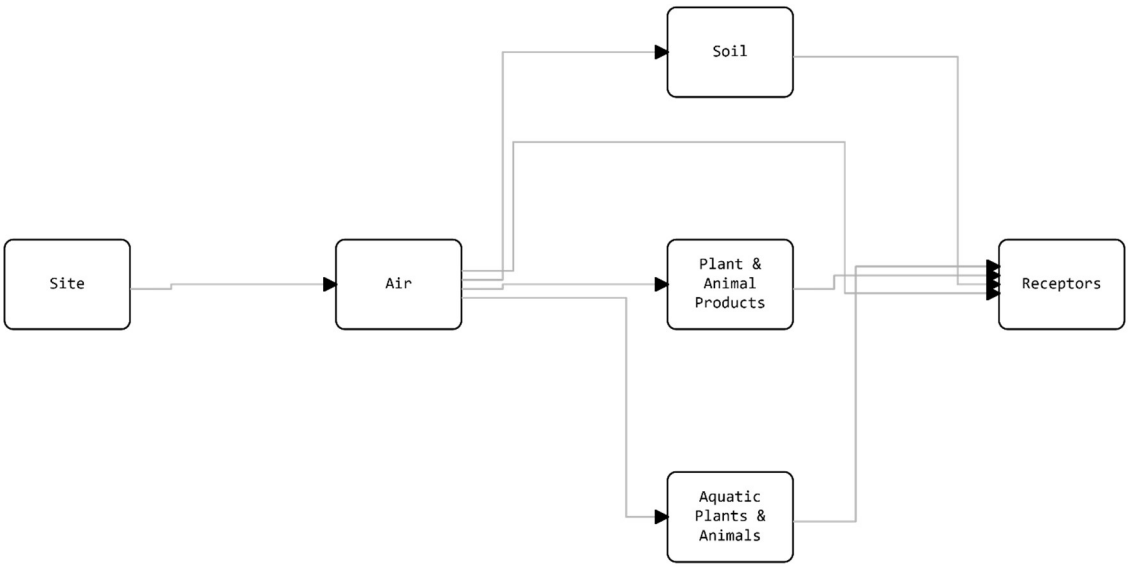
Site -> Air -> Plant & Animal Products -> Receptors

P4: Indirect Exposure from Ingestion of Contaminated Aquatic Plant and Animal Products:

Receptors would be in danger from being externally exposed to radiation indirectly from ingestion of contaminated aquatic plant and animal products, or dermal contact with them.

Site -> Air -> Aquatic Plants and Animals-> Receptors

The Directed Acyclic Graph in the HHRA Example is shown below.



A DAG utility for constructing these drawings is provided in the Tools sub-section. Click here to launch the utility, and tap on Help to launch the Quick User Guide.