

# Journal Clean WAS (JCleanWAS)

DOI: http://doi.org/10.26480/jcleanwas.02.2021.54.57



ISSN: 2521-0912 (Print) ISSN: 2521-0513 (Online) CODEN: JCOLBF

REVIEW ARTICLE

## HUMUS: A MEANS OF ATTENUATING RADIONUCLIDES IN SOILS

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## ARTICLE DETAILS

## Article History:

Received 01 June 2021 Accepted 03 July 2021 Available online 19 August 2021

#### **ABSTRACT**

The ability of humus to suppress the radioactivity of particular radionuclides that could be hazardous to soil health is examined in this review. Industrial and agricultural processes discharge radionuclides into the soil. This, in turn, has an impact on a variety of soil processes, particularly biological activities. The radioactivity of these radionuclides can be suppressed using humus, which is obtained through the decomposition process.

#### **KEYWORDS**

Humus, Radioactivity, Radionuclides.

#### 1. Introduction

Certain elements in the atmosphere and soils are considered unstable because the forces within their nuclei are unbalanced or have an excess amount of energy; in order to become stable, they give off energy or radiation (gamma, beta, or alpha rays); this process of giving off energy is known as radioactive decay, and the elements that undergo this process are known as radionuclides. Some of these radionuclides, such as uranium and radon gas, are found naturally in the cosmic and terrestrial environments (Ojovan and Lee, 2014). Some are cosmogenic isotopes, which are created when a cosmic ray collides with an in-situ atom's nucleus. These isotopes are produced in some materials on Earth, such as rocks and soil, and occasionally in extraterrestrial objects, such as meteorites. Furthermore, human activities greatly contribute to radioactivity; for example, fertilizer manufacture from natural phosphate ore can result in the redistribution of radionuclides in the environment, resulting in increased radiation exposure (Falck et al. 2006; IAEA 2003; Mortvedt 1994).

Some radionuclides like tritium, plutonium, cesium and strontium, are man-made products and can find their ways into the soil through deposition by man, precipitation or by air. Poor disposal of waste without measures to protect the soil and ground water pollution has also contributed to the increased level of radionuclides (Eikelboom et al., 2001, Namasivayam et al., 2001). Enhanced levels of these naturally occurring radionuclides might be present in the soil as well as surface and ground water in areas that are rich in natural radionuclides. Others like the mining and processing activities of uranium ores, drilling, processing and burning of fossil fuels and transportation have raised the concentrations of naturally occurring radioactive materials in the environment (Pujol and Sanchez- Cabeza, 2000; Foland et al., 1995; Avwiri and Ebeniro, 1998). The soil acts can be a basic indicator of the radiological

status of the environment in that it is a source through which radionuclides can be transferred through the food chain to plant and animal depending on the chemical properties of the soil and the uptake process by the roots of plants (Jabbar et al., 2010).

Soil comprises of biotic and abiotic component. The biotic part of the soil is important for various biochemical activities like decomposition and nitrification (Fortuna, 2012). Microbes are biota that we can't see with our naked eyes like bacteria, actinomycetes and fungi all of which are useful in that they influence the structure of soil as well as fertility. Nitrogen fixing bacteria can increase in population over time and consequently released oxygen into the atmosphere (James et al., 2000; Donald, 2014). This led to more advanced microorganisms (Paul, 2015).

## 2. RADIONUCLIDE ON HUMAN AND SOILS

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One of the major causes of internal and external exposure to ionizing radiation is the presence radionuclides in natural sources (Vamoussa et al., 2013). When little amounts of these radionuclides enter the environment, it raises a major concern because the energy they release as they breakdown can be very harmful to microbes, and if high enough can increase the probability of causing cancer and genetic damage (EPA, 2003). Although, work by showed that the presence of these radionuclides is lower than the hazard indices for human, however it was high for microbes (Vamoussa et al., 2013). Effect of radionuclides on microbes depends on the concentration, durability, physiochemical factors and deposition form of the radionuclides (Haas, 2001). Monib and Zayed reported that the higher the exposure of microbes to gamma rays, the greater the damaged caused (Monib and Zayed, 1963). Hussain in 2009 reported that high hits of radiation are likely to cause sufficient mutations to kill microbes.

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Website: www.jcleanwas.com DOI:

10.26480/jcleanwas.02.2021.54.57

Also, a reduction of bacteria, Fungi and actinomycetes on exposure to radiation have been recorded, this is because when high radiation collides with cell, it breaks the structural bonds of cells causing protein destruction and breakage of double and single strained DNA (Daly 2009; Stanovict et al., 1961; Wael and Ghanem 2009). Furthermore, radiolysis generates free radicals which forms hydrogen peroxide ( $H_2O_2$ ) which causes lesions and damage to the microbe's molecular structures (Daly, 2009, Nicastro et al., 2002). A group researcher also reported that nitrogen fixing bacteria are more susceptible to radionuclides (Stanovict et al., 1961). Gamma radiation can affect soil chemical properties particularly the nitrate and ammonium level in soils (McNamara et al., 2003). Ability of soil to bind radioisotopes varies from soil to soil depending on their humus and clay content.

Clay and Humus can influence the distribution of radionuclides between minerals and soil water, this is because clays will tend to bind the radionuclides, keeping it in the soil; soils that have little amount of clay in them will let them reach the water table more quickly (Hosseini and Qureshi, 2011). When radionuclides find their way into lakes or water bodies, they attach and chemically bind themselves to sediments at the bottom of the lake and aggregate particles, particularly the clay part, making them trapped in the lake bottom (Santschi, 1986). In the case of agronomy, if the radionuclides are held tightly by soil mineral, then absorption by soil microbes and crops growing on the soil will be reduced. For example, clay minerals such as vermiculite, illite and montmorillonite can bind tightly to Caesium (Park et al., 2019; Yamamoto et al., 2019).

It has also been discovered that the uptake of radionuclide by the roots of plant is dependent on its presence and abundance in the soil and uptake sensitivity of plant root and are both related to nutrient concentration (Roca and Vallejo, 2000). Best way to get rid of them is to mix up the soil thoroughly by deeply tilling the soil which will put Cs out of reach of shallow rooted crops down to the B horizon where it can bind to clay; hence level of radioactivity in crops will be lowered.

## 2.1 HUMUS and its Benefits

Humus is dark in color and it is formed from decomposition of dead plant and animal. Humus has been found to have a C:N ratio of 10:1 and it is a source of many soil nutrient that are beneficial to plant and soil health (HCME, 2008). Humus when chemically stable is considered to provide both chemical and physical fertility to soils, and also possesses the ability to suppress diseases, as well as improves the water holding capacity of soil by increasing soil micro pores, which generally improves the formation of good soil structure, betters the soil's ability to withstand drought and improves the yield of crops (Dayo-Olagbende et al., 2018, Amodu et al., 2019; (Hargitai,1993; Akingbola and Dayo-Olagbende, 2017; Hoitin and Fahy, 1986; Hogan 2010; De Macedo et al., 2002; Hempfling et al.,; Olness and Archer 2005).

Conversion of soil organic matter into humus involves series of processes, these processes create, supplies and stores nutrients for the use of soil microbes, thereby maintaining high and healthy levels of soil life (*Elo et al., 2006; Vreeken-Buijs et al., 1998*). During humus formation, certain sticky, gum-like materials are released by microbes, these improves the soil structure by binding particles together and allowing greater aeration of the soil (*Caesar-Tonthat, 2002*). As a colloidal material, it can increases the cation exchange capacity of soil, hence by chelation can store nutrient (Michael, 2014). These nutrients are made available to plants and at the same time held in soils to prevent them from leaching by percolating water.

## 2.2 Humus on Radionuclides

Just like clay, Humus is negatively charged and binds to radionuclides. Radioactive and toxic materials like heavy metals and excess nutrients have been found to bind to humus thereby prevented them from leaching into underground water an example is the retention of trace elements found in marshlands and bogs due to high Humus content also relatively low migration capability of <sup>137</sup>Cs can be attributed to its association with humic acids and minerals (*Huang et al., 2008;* Garcia and Garcia, 1993).

It has been found that carbonates, clay content, soil pH and humus content affect the behavior of uranium at a soil layer of 0-20 cm and 60-80 cm (Vukasinovic et al., 2009). The presence of organic matter, inorganic colloids (clay), and competing element will strongly affect the plant uptake of 90Sr and 137Cs by plants from the soil (Varskog et al., 1994).

Literatures by suggested that dark pigmented organisms seem to be more radio resistant than non-pigmented organism (Rokitko et al., 2003; Dadachova et al., 2007). In the light of this it can also be agreed upon that the dark coloration of humus can increase soil radioactive resistivity. Movement of radionuclides down the horizon have been found to be slow and they can be trapped in the upper layer of the soil surface where there are accumulation of litters, organic matters and humus for years, this is why processes such as litter decomposition are suggested for the remediation of radionuclide-contaminated soils (Schaller et al., 2014; Zhu and Shaw, 2000; Konopleva et al., 2009; Drissner et al., 1998; Rafferty et al., 1997). The transport of some radionuclides through soil organic layers to the root of plant can take a long time; this is as a result of the complexity of the humus elements. Two main buffers have been discovered for radionuclide uptake or movement, they are the soil structural component and humus (Garcia and Garcia, 1993).

#### 3. RECOMMENDATION

Human activities are bound to release radioactive materials into the air and environment which eventually find its way into the soil. Advancement in technology and civilization lead to invention of radionuclide releasing materials like atomic bombs, cell phones, fertilizers and many more. All of which increase deposition of radionuclides in soil. Humus can be a good material to attenuate these radiations in soil so as to keep the soil alive. Furthermore, Humus has been found to have many beneficial influences on physical, biological and chemical properties of soils.

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