الأسبوع الخامس و السادس

Chapter Three (Detection of Radiation)

3.1 Indicators of Radiation Pollution

Radiation pollution levels can be measured directly. The presence or absence of certain living organisms can also act as an indicator of the amount of radiation pollution.

Plants consider are efficient, cheap and natural available monitor systems or bioassays for level of radiation pollution. The type and concentration of pollutants can be reliably found out by various characteristics damage symptoms produced in the plants because such damage symptoms are pollutant specific as well as concentration specific.

The accumulation of radionuclide by plants acting as a monitoring system in the environment may occur by two modes; foliar absorption by the leaves and shoot of the plant, or by root uptake from the soil. Data on plant accumulation of radionuclides may be obtained from studies of fission product radionuclides deposited as worldwide fallout, and from tracer studies of plant physiology.

The role of plants as monitors of radionuclides is twofold: as monitors of recent atmospheric releases of radionuclides; and as indicators of the long-term behavior of aged deposits of radionuclides in the soil.

Also the animal species which can be used as biological indicators of radionuclide contamination.

The pollen-bee-honey using to study movement of radioactive elements in the plant-animal-man food chain. Pollen, bees, and honey are collecting from different locations at a nuclear facility. The pollen is a more sensitive indicator of pollution than bees or honey. If pollen monitoring shows that, an area has become polluted.

The effects of radiation doses on organisms differ from specie to others, so that the effects of radiation on microorganisms are utilizing to detect and assay the radiation level. Some of species are sensitive to radiation pollution, for that it's using to detect the radiation at low level, on the other hand, some of species can resist the radiation, then it's using to determine the radiation at intermediate and high level.

3.2 Method of Detection

To tackle the problem of environmental pollution, the reliable methods of detection and identification of pollutants must be research. In the last 40-50 years, a large number of analytical methods for the detection of radioactive contamination have been developed. For example, different types of penetrative radiation (α, β, γ, or neutron) can be detected using physical, chemical and biological methods,

Belong of the biological method; there are many organs and microorganisms being using as indicators for radionuclide contaminations, for example the blood, skin tissue and the bacteria or DNA as microorganisms technique. The E. coli bacteria response for ionizing radiation been using as bioassay at low level of radiation pollution. In contrast, the Dinaccocas Radiodurans bacteria were utilizing for detect the radiation pollution at intermediate and high level of pollution.

Chemical methods focus on the analysis of sample for their radionuclide content. Various methods are employed to purify and identify the radioelement of interest through chemical methods and sample measurement techniques.

Physical method employing various techniques and devices for this purpose, there are a large numbers of detectors are using for radiation detection.

3.3 Detectors and Measurements

Radiation cannot be detected by human senses. A variety of handheld and laboratory instruments is available for detecting and measuring radiation. The most common handheld or portable instruments are:

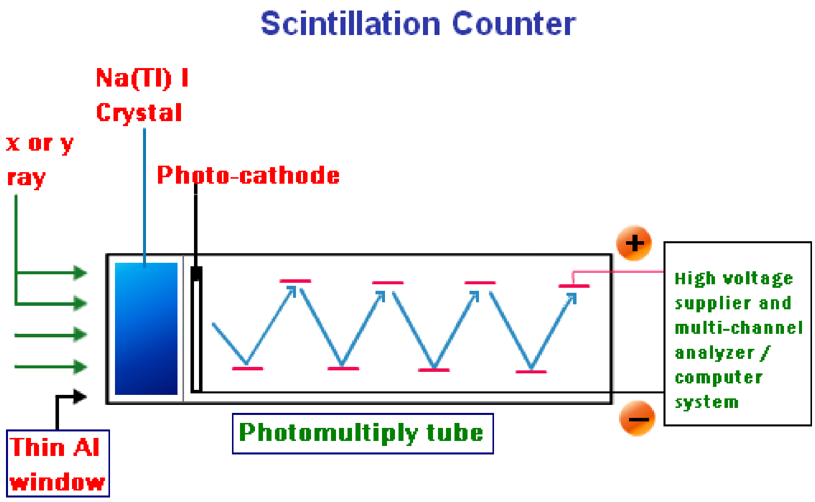
3.3.1 Scintillation counters

A scintillation counter is an instrument for detecting and measuring ionizing radiation by using the excitation effect of incident radiation on a scintillator material, and detecting the resultant light pulses.

It consists of a scintillator which generates photons in response to incident radiation, a sensitive photomultiplier tube which converts the light to an electrical signal and electronics to process this signal.

Scintillation counters are widely used in radiation protection, assay of radioactive materials and physics research because they can be made inexpensively yet with good quantum efficiency, and can measure both the intensity and the energy of incident radiation.

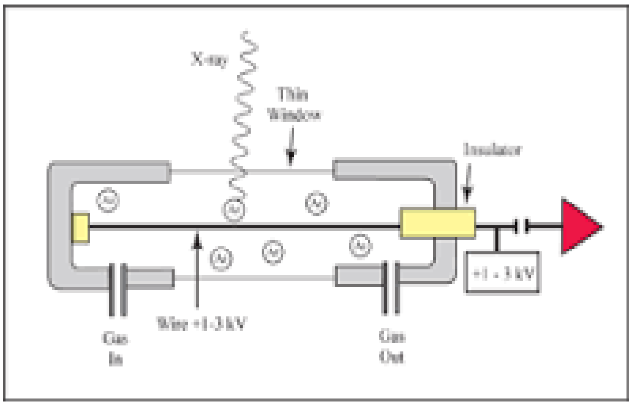
When the radiation interacts with certain materials flashes of light can be seen, the phenomenon called 'scintillation". Detection of these flashes either by the naked eye or with the help of optical instrumentation was one of the oldest methods of radiation detection. Rutherford used a ZnS scintillating screen, and employed this method to count the scattered alpha particles in the historic alpha-scattering experiment. This method is tedious and very crude and was soon replaced by gas counters, where the counting is done electronically and additional information about the energy of radiation can be obtained if needed. In 1944, Curran and Baker started using a photomultiplier in scintillating chambers, and later Kallman replaced ZnS crystals with naphthalene. These two changes revolutionized scintillation detection, making it possible to electronically detect, record, and analyze pulses produced by radiation.



Scintillation Counter Diagram

3.3.2 Gas counters

Geiger from Rutherford's laboratory developed gas counters for the detection of radiation in 1908. These counters became practical for the measurement of radiation shortly thereafter, even though scintillates were for a long time in use for this purpose. The original Geiger counter consists of a glass cylinder (containing idle or rare gas), an outer cylindrical electrode and an inner wire electrode, with a potential difference applied between them. Geiger found that radiation causes the ionization of gas and therefore an electric current between electrodes, which was detectable with an electrometer of "moderate sensibility". The amount of charge (current) depends on the amount of radiation energy penetrating the gas tube.



Gas detector diagram

The Geiger-Müller tube is filled with an inert gas such as helium, neon, or argon at low pressure, to which a high voltage is applied. The tube briefly conducts electrical charge when a particle or photon of incident radiation makes the gas conductive by ionization. The ionization is considerably amplified within the tube by the Townsend Discharge effect to produce an easily measured detection pulse, which is fed to the processing and display electronics. This large pulse from the tube makes the G-M counter relatively cheap to manufacture, as the subsequent electronics is greatly simplified. The electronics also generates the high voltage, typically 400–600 volts, that has to be applied to the Geiger-Müller tube to enable its operation.

3.3.3 Semiconductor Detectors

A semiconductor detector is physics device that uses a semiconductor (usually silicon or germanium) to measure the effect of incident charged particles or photons.

The operation of a semiconductor detector is analogous to the operation of an ionization chamber. In contrast to ionization chambers, where the incident radiation produces positive ions and electrons, in semiconductor counters radiation produces electrons and holes, contributing to the electric current.

One major difference, of course, is that only 3.5eV is required to produce an electron-hole pair in semiconductor detectors, while 30eV is needed for the ionization of gas. The lower energy increases the number of electron-hole pairs per MeV of radiation and thus increases the sensitivity of radiation detection.

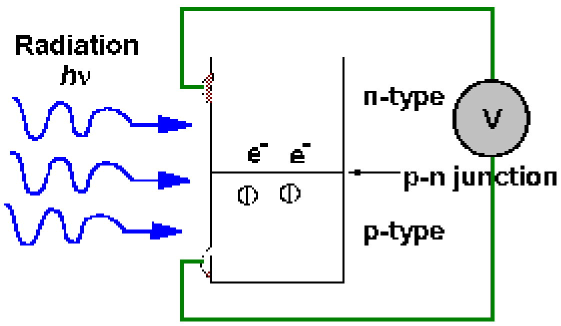


Illustration diagram for semiconductor detector

Semiconductor detectors are considering acceptable sensitive detectors, therefore it has a broad application during recent decades, in particular for gamma and X-ray spectrometry and gas particle detectors.

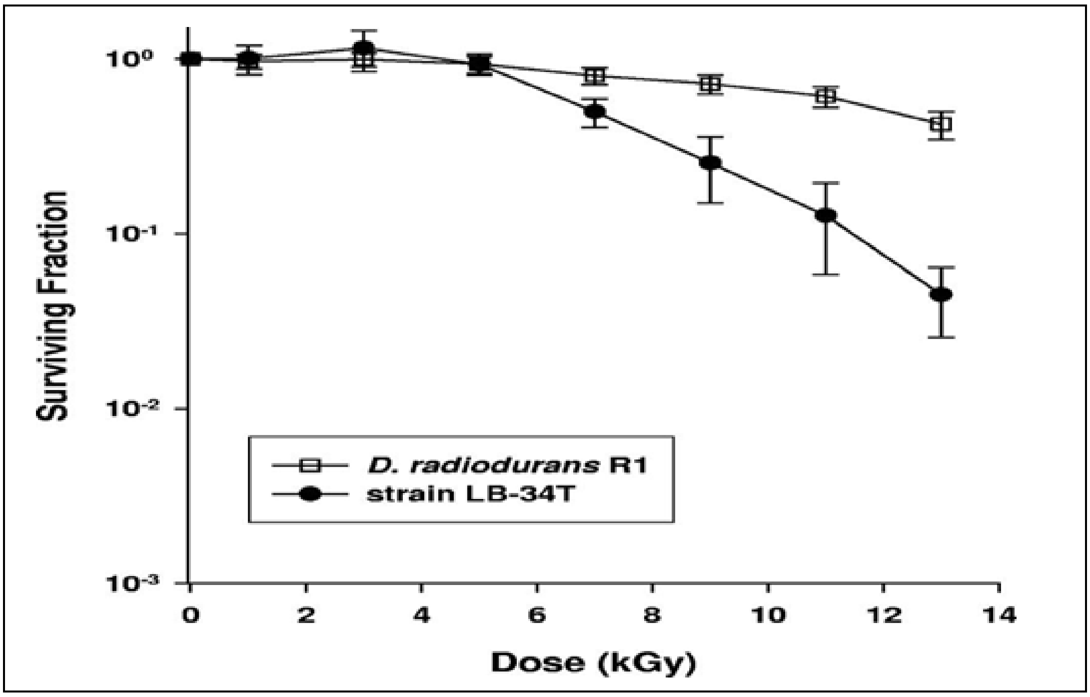
However, very often these methods require the use of much equipment assistance in laboratories and well-trained personnel, and thus cannot be used, for example, in the water environment. Thus, the use of natural systems for sensing, such as microorganisms or bacteria, can be advantageous. It is known that microorganisms (bacteria) might be badly affected by radiation and some of the chemical pollutants.

Such negative effects depend on the radiation level and concentration of pollutants: the damage could range from partial loss of functionality at low doses (concentrations) up to the “death” of bacteria at high doses (concentrations). Therefore, the monitoring of bacteria counts in natural water resources could serve as a simple method for preliminary detection (or screening) of pollutants. In a simple scenario, a low bacteria count in a particular water sample can give an indication (warning) of the presence of some type of contaminant of either a radioactive or a toxic nature,

The development of this new method has allowed estimating radioactive contamination levels on environment.

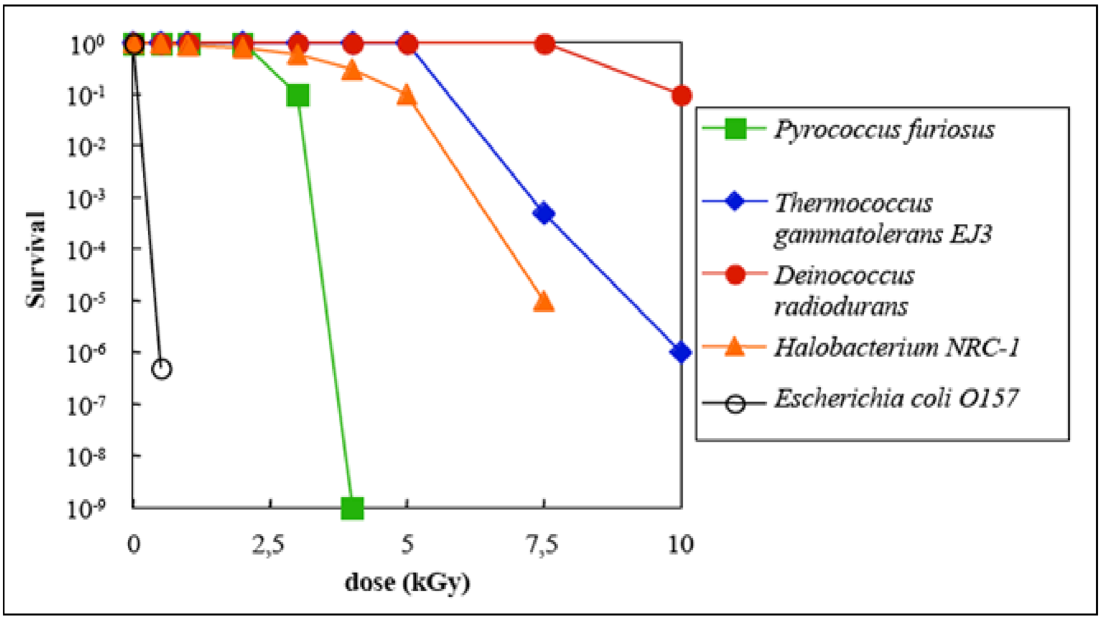
The main effects of radiation are cytotoxic and mutagenic ones, which are principally the result of DNA damage caused during the radiation exposure. This might not always be the case, since environmental organisms, such as Shewanella oneidensis, which encode relatively complex DNA repair systems, are killed at radiation doses that cause relatively little DNA damage.

The survival percentage of Escherichia coli, Deinococcus radiodurans and S. oneidensis due to the effect of ionizing radiation has been using. Results show that 90% of S. oneidensis cells do not survive 70 Gy Gamma-ray radiations, 10% of D. radiodurans cells survive 12,000 Gy, and 10% of E. coli survives 700 Gy. Moreover, S. oneidensis bacteria die after exposure to radiation and desiccate for only one day, whereas similarly treated D. Radiodurans can survive for months.



Survival curves for (radiation resistant bacteria) D. radiodurans strains R1 and LB-34T

Deinococcus radiodurans, as mentioned, is a Gram-positive bacterium well known for its ability to survive extreme doses of ionizing radiation. Though Deinococcus radiodurans is highly resistant to a broad spectrum of DNA damaging agents, it can recover from particularly high doses of ionizing radiation, which is known for producing dsDNA breaks. Since high doses of radiation lead to 150-200 dsDNA breaks per chromosome in Deinococcus radiodurans, radio-resistance is largely due to highly proficient mechanisms of DNA repair. By contrast, Escherichia coli can survive only a few dsDNA breaks at a time.



Survival curves for Pyrococcus furiosus, T. Gamma tolerance, D. Radiodurans, Halobacterium, and E. coli, following exposure to γ radiation

For that, the response of bacteria to radiation pollution, being utilizing to estimate the pollution level and using as a biosensor to detect the radiation pollution in environment.