WASTEWATER TREATMENT USING IONIZING RADIATION TECHNOLOGY: A REVIEW

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Abstract: The use of ionizing radiation techniques in different fields have proved their reliabilities and sustainability over decades. But the extent and the variability of these applications are still probably not known to the masses. Actually there are only few areas e.g. agriculture, medicine, industrial production, hydrology and environmental control which has been influenced by the use of radiation techniques. However the potential of this part in the nuclear technology has by far not been exhausted yet. The present work illustrate the recent advances in the treatment of wastewater using different ionizing radiation techniques.

***IndexTerms* – Wastewater, Ionizing radiation, Electron beam irradiation, Gamma irradiation.**

I. INTRODUCTION

Water is most important to all the living organisms and 75% of the earth surface is covered with water; but out of this, only less than 3% of the water is suitable for human consumption and survival of plants and animals. Out of this much percentage, most of the fresh water is frozen in ice sheets and perennial snow.

Unfortunately, the fresh water is being polluted by the civilization extensive in different ways, for example, in the journey of Ganga from Devprayag numerous Hydel Projects are depleting the environmental flow. In addition to it, untreated effluents from numerous industries like leather, textiles, and sugar mills etc. release toxic chemicals into the water bodies. Inappropriate management of textile, industrial and municipal wastewater is one of the major causes of water pollution. It is estimated that 300-400 million tons of heavy metals, solvents, toxic sludge, and other wastes from industrial activities are dumped annually into the world's water resources. Fertilizers entering coastal ecosystems have produced more than 400 'dead zones' in the oceans, which is more than 245,000 sq. km (Paul 2017).

Every civic department is expected to provide drinking water to its inhabitants and clear the originated waste. Most of these societies just dump the sewage in the nearest water body. The sludge have a very heavy load of harmful pathogens, antibiotics, and toxic chemicals, including dyes from textile industry and metals like chromium from leather industry. Which get back into our food chain and cause a havoc. This toxic water is also contaminating our underground water sources. Several chemical methods as well as special filters are available for this, which must be implemented in all the industrial plants. However the implementation of these techniques are very poor.

These sewage treatment plants operate on a simple principle. The wastewater along with the sewage is put in a (primary) tank, where the sludge part settles down. The remaining liquid waste is then taken to (secondary) biozone chamber. In the chamber, a pump airs the waste and encourages 'friendly bacteria' to condense the organic matter. This breaks these down and purifies the water, which can then be used for irrigation or for flushing in toilets. The sludge can be used as a fertilizer or even as fuel in a biogas plant, where the residue can again be used as fertilizer (Ouano 1983).

Such treatment plants must be installed in all housing societies to conserve the major portion of the usable water. In most developed nations, these are installed on a large scale and the water is reused several times for flushing before being finally discharged.

The sludge and the wastewater being released into water bodies can be more easily and most effectively treated to yield valuable and safe fertilizers and safe water for irrigation using nuclear radiations (Cieślik et al. 2015).

In many countries the treatment of wastewater using radiation technology is under study. It is painful to note that very efficient modern techniques using radiation from ^{60}Co, electron beam irradiation etc. for the treatment of wastewater and sludge are known from decades but are not employed on a large scale. We urgently need that the governments and municipal bodies in India must use these valuable techniques and employ it across the nation to solve this problem once for all and safeguard the health of its citizens.

The focus of the present work is to review the use of various ionizing radiation techniques for the purification of wastewater. The applications of this technology for the treatment of wastewater and sludge will not only help the development of technical process but also give great acceptance of technology as engineering needs.

II. REVIEW OF LITRATURE

Irradiation facilities for the treatment of wastewater have been constructed in many countries of the world. A review of state-of-art of technology for irradiation treatment of water and sludge by four types of radiations namely: UV, radioactive isotopes (^{60}Co), linear accelerators, and X-ray machines was published by the American Society of Civil Engineers in 1992 (Swinwood et al. 1994).

The first large scale plant was Geiselbullach Gamma Sludge Irradiator, constructed in Germany in 1973. ^{60}Co was used as the source material. The plant was designed for the mechanical and biological treatment of 50,000 m^3 of sewage water per day, the equivalent of approximately 2,50,000 inhabitants. In 1984, ^{137}Cs was added to the facility to supplement the existing ^{60}Co sources (Lessel et al. 1997).

In India, Sludge Hygienisation Research Irradiator (SHRI) is operating at Vadodara for radiation treatment of raw sludge containing 3-4% solids since last 30 years. SHRI forms part of the programme of Bhabha Atomic Research Center, Mumbai. The main objective is to treat the entire sludge output of about 110 cubic meters per day from Gajerawadi Sewage Treatment Plant and use the hygienized sludge as a safe fertilizer. They reported that about 3 kGy of absorbed dose in sewage sludge removes 99.99% of pathogenic bacteria. They also observed that SHRI produces high value manure on large scale and its operation is smooth in handling of plant (Swinwood et al. 1994).

After the successful running of SHRI, Bhabha Atomic Research Centre has been planning to set up a plant loaded with 150 kCurie of ^{60}Co in collaboration with Amdavad Municipal Corporation, Ahmedabad. The Hygienised and Enriched Sludge (HES) from the plant will be used as organic manure for horticulture and agricultural applications.

The wastewater and the sewage water can be treated with high current electron beam to kill bacteria and pathogens, so that the water can be safely used for irrigation. The Electron Beam treatment breaks complex molecules of dyes and other chemicals into harmless simple molecules. The most significant improvements can result in decolorizing and destructive oxidation of organic impurities in wastewater.

In Daegu, South Korea, the first industrial plant for the treatment of textile dye wastewater using an electron beam was started in 2004, and finished December 2005. Its capacity is 10,000 m^3 of wastewater per day using 1 MeV, 400 kW accelerator. This facility is further combined with biological treatment and has shown a high reduction of chemical additive consumption (Han et al. 2005).

Y. Mohammed and R. Firas studied the use of ionizing radiation technology for treating municipal wastewater. For this study samples have been collected from AL-Rustamia wastewater treatment plant in Baghdad city. They investigated that, irradiation by gamma radiation with a dose ranging from 100 to 500 krad was efficient in reducing some of the physical contaminants. The organic contaminants were degraded and reduced to about 12% of their original concentrations. Further they added that, an experimental pilot plant study is required to optimize the cost of wastewater treatment through the use of this technology (Mohammed et al. 2006).

Tahri et al., investigated the gamma irradiation effects on wastewater. For this the samples were collected from urban wastewater treatment station of Tetouan, Morocco. These samples were irradiated at different doses ranging from 0 to 14 kGy using a ^{60}Co gamma source. They investigated that an elimination of bacterial flora, a decrease of biochemical and chemical oxygen demand, and higher conservation of nutritious elements. The results of this study indicated that gamma irradiation might be a good choice for the reuse of wastewater for agricultural activities (Tahri et al. 2010).

In Saudi Arabia, a comparative study was carried out between the electron rays (e-beam) and gamma rays (^{60}Co) for sterilization of both of wastewater and sludge samples from Al Hofuf wastewater treatment plant. It was found that a 16.2 kGy dose is generally suitable for the wastewater sterilization and it could be raised to above 25 kGy in case of only secondary treatment stage is applied and 27 kGy for sludge (SAL= 10^{-6}). This will reduce the chlorine poisons. This study demonstrated the potential of ionizing radiation to disinfect sewage and sludge and to increase the water quality in the wastewater by lowering the total heterogeneous bacteria. Moreover it was added that, the only way for sludge sterilization is gamma rays and no other method is comparable to this (Sabbagh et. al. 2014).

Lee et al., gave a comparative study of disinfection efficiency and regrowth control of microorganism in secondary wastewater effluent using UV, ozone, and ionizing irradiation process and they investigated that the disinfection efficiency using ionizing radiation was not affected by the seasonal changes of wastewater characteristics, such as temperature and turbidity. They concluded that, the ionizing radiation requires two or three orders of magnitude lower power consumption than UV and ozone. Therefore, ionizing radiation can be applied as an effective and economical alternative technique compared to other conventional disinfection processes (Lee et al. 2015).

The influence of gamma irradiation was also investigated on natural dyeing properties of cotton and flax fabrics. Chirila et al., investigated the effect of gamma radiation on fabric made up of 100% cotton and 100% flax. The radiation doses were varied from 5 to 40 kGy, using a Co-60 research irradiator. It has been found that Gamma ray treatment of 40 kGy was the most effective in the case of fabrics made from 100% cotton, enhancing the colour strength. The gamma irradiation increased the uptake of natural dyes on natural cellulosic fibers (Chirila et al. 2018).

The review of different publications by different research groups are supporting the use of irradiation of wastewater is a much safer and efficient technique over the old methods using chemical treatment of wastewater. In light of the several advantages of radiation technology has so far proved to be the best option all over the world in the context of wastewater treatment procedures.

There is an urgent need to install these plants at all large cities of the country and convert the sludge to a valuable fertilizer, instead of releasing this toxic waste into the farms. This is an effective, economical, reproducible, scalable, and safe management process of sewage sludge treatment for industrial as well as agricultural applications.

III CONCLUSION

The whole world scientists are searching state of the art technologies which provide efficient, safer, economical and fast solutions to the every problem faced by the society. In the present review it was seen that electron beam treatment is an eco-friendly and cost-effective method of wastewater treatment. In addition to this, it saves the treatment time and cost for chemical solution and most important thing is that no secondary waste is generated using this method. Furthermore, the efficiency of gamma radiation irradiation of sludge is found to be the most suitable method than pre-existing procedures. This treated waste water can be safely used in agriculture and in the industry. In view of these advantages it is concluded that suitable radiation treatment of waste water is most useful method for sustainable management of waste water for the whole world. However it should largely be used by those nations where at least water resources are lesser as compared to the other countries.

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