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PESTICIDE INDUSTRIAL EFFLUENTS AND BIOLOGICAL TREATMENT

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ABSTRACT

The rapidly growing industrialization along with an increasing population has resulted in the accumulation of a wide variety of chemicals. Mismanagement of industrial effluents has resulted in polluted groundwater, streams, lakes and rivers as well as damage to wildlife and vegetation. Meanwhile, high levels of toxic contaminants have been found in animals and humans, Thus, the frequency and widespread use of man-made "xenobiotic" chemicals has led to a remarkable effort to implement new technologies to reduce or eliminate these contaminants from the environment. Effluent discharge practices in India are too crude and society is in danger, especially in the industrialized part of the cities. The aim of biological treatment of industrial effluents is to remove or reduce the concentration of organic and inorganic compounds.

Keywords: Pollution, Environment, Effluents.

INTRODUCTION

The pesticide industry is an important part of the economy. The major components of the pesticide industry include manufacturing and formulation packaging. Formulating Packaging plants blend chemicals with other active or inactive ingredients to achieve the end products [18]. Rapid industrialization and improper discharge of industrial effluents, wastes, refineries, oil terminals, and petrochemical plants accidental spills or deliberate release of certain hazardous chemicals that are mutagenic, carcinogenic and recalcitrant, pose a serious threat to environment including soils, groundwater as well as open water bodies [15] .These effluents have a variety of unusual chemicals including a range of aromatic hydrocarbons and their derivatives [6]. Increased industrial activities have led to pollution stress on surface waters both from industrial, agricultural and domestic sources. Wastes entering these water bodies are both in solid and liquid forms. As a result, water bodies which are major receptacles of treated and untreated industrial wastes have become highly polluted. The resultant effects of this on public health and the environment are usually great in magnitude [13]. High levels of pollutants in river water systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), toxic metals such as Cd, Cr, Ni and Pb and fecal coliform and hence make such water unsuitable for drinking, irrigation and aquatic life. Industrial effluents are a main source of direct and often continuous input of pollutants into aquatic ecosystems with long-term implications on ecosystem functioning including changes in food availability and an extreme threat to the self-regulating capacity of the biosphere. Wastewaters from industries and residential areas discharged into another environment without suitable treatment could disturb the ecological balance of such an environment [10]. Some heavy metals contained in these effluents have been found to be carcinogenic while other chemicals equally present are poisonous depending on the dose and duration of exposure. Industrial effluents are also known to exhibit toxicity toward different aquatic organisms. The coastal residential environment in any industrial effluent site is always under considerable stress due to the prevailing harsh environmental conditions, especially high temperature and salinity. The effluents from pesticide industries mainly consist of a mixture of intermediates, by-products, starting materials, pesticides and related compounds. Effluents from pesticide industries are a serious environmental hazard due to their toxic nature and high organic content. These waste waters need to be effectively treated before being discharged into water bodies [4]. All industries in India, all rivers are polluted in most of the stretches by some function under the strict guidelines of the Central Pollution Control Board (CPCB) but still the environmental situation is far from satisfactory. Most major industries have treatment facilities for industrial effluents but this is not the case with small scale industries which cannot afford enormous investments in pollution control equipment. As a result there are sufficient evidences available related with the mismanagement of industrial wastes [14].

Characteristics of Industrial Effluents

Industrial effluents are characterized by their abnormal turbidity, conductivity, chemical oxygen demand (COD), total suspended solids (TSS), biological oxygen demand (BOD), and total hardness. Industrial wastes containing high concentration of microbial nutrients would obviously promote an after-growth of significantly high coliform types and other microbial forms [10].

Industrial effluent characteristics provide basic information about the integrity of the aquatic habitat within such rivers and streams into which they are discharged. Although, the physicochemical analysis of the effluents indicates that most of these industries conform to the recommended FEPA guidelines, however, exceptions occur in the total dissolved solids (TDS) and Nitrate ($NO3^-$) contents. These are found to be very high in most of the effluents sampled to which humans and the aquatic habitat are adversely affected [9].

The pH analysis of such effluents shows that effluents from food and beverage industries tend to be abnormally very acidic .An important pollution index of industrial wastewaters is the oxygen function measured in terms of chemical oxygen demand (COD), and biological oxygen demand (BOD), while the nutrient status of wastewater are measured in terms of nitrogen and phosphorus. In addition, other important quality parameters include pH, temperature and total suspended solids [10].

Recommendations

Under Section 304 of the CWA, USEPA was required to establish “effluent guidelines” for a number of different industrial categories by specifying the effluent limits. Two types of standards were required for each industry:

(a) Effluent limitations that require the application of the best practicable control technology (BPT) currently available, and

(b) Effluent limitations that require application of the best available technology (BAT).

Effluent limitations reflecting BPT currently available for the pesticide manufacturing and formulating industrial category were promulgated by USEPA on April 25, 1978 (43 Federal Regulation 17,785, 1978). The pesticide industry was divided into three subcategories under the BPT regulations: (a) Organic pesticide chemicals manufacturing, (b) Metallo-organic pesticide chemical manufacturing, and (c) Pesticide chemicals formulating and packaging. The BPT regulations are based on pesticide removal by hydrolysis or adsorption followed by biological treatment [9].Table.1 presents the Environmental Standards of pesticide industry effluent for the organic pesticide chemicals manufacturing subcategory. Limit should be complied with at the end of the treatment plant before any dilution [15].

Table 1: Environmental Standards of pesticide industry effluent

S.No.	Parameter	Concentration not to exceed, mg/l (except pH)
(i)	Compulsory	
	pH	6.5-8.5
	BOD (3 days at 27^{o}C)	100
	Oil & grease	10
	Suspended solids	100
(ii)	Bioassay test	Minimum 90% survival of fish after 96 hrs with 90% effluent and 10% dilution water. Test should be carried out as per IS:6502? 1971
(iii)	Additional (a) Heavy Metal	
	Copper	1.0
	Manganese	1.0
	Zinc	1.0
	Mercury	0.01
	Tin	.1
	Any other like nickel	shall not exceed 5 times the drinking water standards (BIS) individually
	(b) Organics	
	Phenol & Phenolic	1.0
	compounds as C6H5OH	
	(c) Inorganics	
	Arsenic as As	0.2
	Cyanide as CN	0.2
	Nitrate as NO_3	50
	Phosphate as P	5.0

Treatment of Industrial effluent

Rapid population and Industrial growth is posing challenges in Water and Effluent management. There is also scope for updating the existing technologies which will help in reduction of raw materials consumed and minimize waste generation. Effluent can be treated in a number of different ways depending on the level of treatment required. In biological treatment, some of the microbes like actinomycetes, filamentous fungi, soil micro-organisms, bacterial enzymes and streptomycetes that help in biological degradation [12].

Biological treatment

Biological treatment process can take many forms but all are based around microorganisms, mainly bacteria. These microorganisms use components of the effluent as their food and break them down to fewer complexes and less hazardous compounds. There are two main types of processes, these involve suspended microbial growth (e.g. activated sludge) and attached microbial growth (e.g. fixed film).These are approaches large populations of microorganisms and brought into contact with effluent in the presence of an excess of oxygen. Suspended growth systems microbes grow in small aggregates or “flocs” .Activated sludge leaves the reactor with the treated effluent but is settled out in a clarifier and returned to the aeration unit to recycle the bacteria. And in fixed film systems the microbial population grows as a thin layer (a bio-film) on the surface of an inert support medium [8].

Biological treatment processes are widely used throughout the pesticide industry to remove organic pollutants measured by parameters such as BOD and COD. These processes are probably the most cost effective techniques for treating aqueous waste streams containing organic contaminants [11]. Some materials that may inhibit or interfere with biological treatment are heavy metals, cyanides, chlorinated organic compounds, and high salt content (.20, 000 to 30,000 mg/L) [9].

Biological treatment plants must be carefully managed as they use live microorganisms to digest the pollutants because some of the compounds in the wastewater may be toxic to the used bacteria. It is also important to monitor and control pH as adverse pH may result in death of the microorganisms. The ETP must be properly aerated and must be operated 24 hours a day, 365 days a year to ensure that the bacteria are provided with sufficient food and oxygen to keep them alive. Normally materials such as urea and ammonium phosphate are added. It is possible to replace these nutrients by substituting the liquid portion of effluent from toilets, which is rich in nitrogen and phosphorus containing chemicals but their solid portion may cause problems [12]. According to Metcalf & Eddy (2003) a properly designed biological ETP can efficiently satisfy BOD, pH, TSS, oil and grease requirements. Most of compounds in industrial wastewater may be toxic to the microorganisms so pretreatment may be necessary.

Many pesticides are complex compounds that may not be easily biodegraded. Some factors that affect biodegradability include Solubility and availability, molecular structure, substitutions, functional groups [5]. Under proper conditions, biological treatment effectively removes priority pollutants, nonconventional pollutants (TOC) and conventional pollutants (e.g., BOD). The mechanism of pollutant removal may be one or more of the following: (a) biological degradation of the pollutant, (b) adsorption of the pollutant onto sludge, which is separately, disposed(c) volatilization of the pollutant into the air [9]. The basic units needed for biological treatment are screening, equalization, pH, aeration and settling unit. Output quality from biological treatment can satisfy the national standards for most of the required parameters except color.

The USEPA surveys identified 31 pesticide plants using biological treatment processes to treat wastewater effluents which including: (a) 14 aerated lagoon systems (b) 13 activated sludge systems and (c) four trickling filter systems. Biological treatment is the potential toxicity of pesticides which could inhibit microorganism growth. The use of powdered activated carbon (PAC) in combination with activated sludge is a biophysical process that has high potential to improve biological treatment for pesticide wastewater due to the adsorption of toxic compounds by activated carbon. The PACT process has not been widely used on a full-scale basis in the pesticide industry [16]. Another important advance in biological treatment is the use of membrane bioreactors (MBR). The MBR uses a UF membrane system immersed in an aeration tank to accomplish both biochemical oxidation and excellent solid/liquid separation, without the need for a separate clarification step The MBR can offer reliability, compactness, and excellent treated water quality as the MBR effluent is of UF permeate quality[17].

All biological-treatment processes take advantage of the ability of microorganisms to use diverse wastewater constituents to provide the energy for microbial metabolism and the building blocks for cell synthesis [3].It is removing substances that have a high demand for oxygen from the system through the metabolic reactions of the microorganisms, the separation and settling of activated sludge solids to create an acceptable quality of wastewater effluents, and the collection and recycling of microorganisms back into the system or removal of excess microorganisms from the system[1].

Microbial degradation

Pesticide degradation in soils occurs via abiotic (chemical) and biotic (microbial) processes. These two degradation processes can take place simultaneously and are potentially influenced by effluent irrigation. Biological degradation, either complete mineralization form metabolites, strongly interacts with sorption and transport processes. Microorganisms including bacteria, actinomycetes, fungi and algae are the major agents involved in biological degradation. Three types of microbial transformation can be distinguished: (i) biodegradation (ii) co-metabolism (iii) bioaccumulation. Bioavailability of pesticides plays an important role in their biotic degradation. Soil microbial activities are strongly influenced by temperature, soil water content, soil pH, nutrient availability, and size and species composition of the microbial population and the chemical nature of the pesticide itself. The presence of pesticides can enhance or reduce microbial activity depending on their bio-toxicity. The rate of degradation of pesticides as measured by half life is usually obtained by laboratory degradation studies, where samples spiked with a known amount of the pesticide are incubated at preset environmental conditions (temperature, soil water content and light regime) and the change in pesticide concentrations is monitored over a set period of time.

Effluent irrigation can modify the microbial degradation of pesticides through a number of processes including changes in the size and composition of microbial populations, enhancing nutrient and moisture status of the soil and providing excessive carbon as an energy source. Effluent impacts on soil flora and fauna are inconsistent. The interactions of pesticides with microorganisms are not easily predictable. Microorganisms are the major agents involved in the degradation of many pesticides in the soil environment, thus an increase in microorganisms through effluent-borne microbes may positively contribute to the overall pesticide degradation. The introduction of microbial organisms through effluents was also reported to induce competition amongst indigenous and induced microbes resulting in shifts in the composition of the communities. The applied effluents may also be highly bio-toxic due to heavy metal and organic residues content and decrease microbial communities. Soil microorganisms require water for their metabolic processes and respond to changes in soil moisture, especially to extreme moisture conditions. Irrigation was reported to increase the number of bacteria by 50% .An increase of nutrient content through effluent irrigation is likely to supply organic substrates for soil microorganisms, thereby stimulating the turnover of organic matter.

RESULT AND DISCUSSION

Basically the bacteria are responsible for the degradation of organic and inorganic compounds. They derive their nutritional requirement from the compounds presented to them in the effluent waste. They are able to synthesize their enzymes, metabolic intermediates, structural proteins, lipids and nucleic acids from carbon compound in the other elements.

Many research reported that a large number of bacterial species isolated from different industrial effluents.*Pseudomonas* species are regarded as one of the most common species of bacteria degrading phenolic compounds isolated from contaminated sites of different industries Environmental problems caused by the industrial effluents is mainly due to accumulation of pollutants and other fragmented compoundsand finally they are forming a xenobiont. There is a quick need to degrade these xenobiotic compounds in an eco-friendly way. Various techniques like biological treatment, chemical treatment, microbial remediation, phytoremediation and their subtypes have been used. Since the industrial revolution, industrial and mining operations have been accompanied by a problem: industrial waste which may be toxic, ignitable, corrosive or reactive. If improperly managed, this waste can pose dangerous health and environmental consequences.

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