

STUDY ON PHYSICO-CHEMICAL PARAMETERS OF WATER EFFLUENTS FROM PHARMACEUTICAL INDUSTRIES IN ILORIN, NIGERIA

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Abstract

The present research work deals with the study of some of the important physico-chemical parameters of industrial effluents collected from pharmaceutical industries in Ilorin, Kwara state. The study reveals that the pharmaceutical industries are responsible for polluting the surrounding aquatic environment. It was observed that pH values of effluent samples collected from the pharmaceutical industries were slightly lower than pH of 6.5 to 8.5 as recommended by ISI and WHO. The effluent samples collected shows extremely high Total Dissolved Solid (TDS) content range of 168.25 – 197.42 mg/L and correspondingly high Total Solid (TS) content of 169.16 – 198.63 mg/L. The chloride content in the effluents was 230, 240 and 300 mg/L which were slightly higher than acceptable limit of 200 mg/L set by WHO. The BOD values of effluent samples collected were 1430, 1475 and 1627 mg/L respectively which lie above the maximum permitted BOD content of < 100 to 300 mg/L. The COD values in the different effluent samples were also very much higher than maximum permissible limit of 40 mg/L according to NESREA Standard. The overall results of this study clearly indicated that effluents from these pharmaceutical industries were highly polluted hence, they have resulted in pollution of nearby water body thereby affecting the growth of vegetation and aquatic life. The results of the present investigation point out the need to implement common objectives, compatible policies and programs for improvement in the industrial waste water treatment methods.

Introduction

In Nigeria, industrial growth is identified as a major tool for economic development [Aina 1992; Adeyeye (2002)]. The production of useful consumer products is the indicators of this growth. Nevertheless, waste generation is also a function of every industrial process. Ironically, these industrial corporations does not consider adequately the functionality of their waste treatment plant so as to accommodate basic treatments such as sedimentation, sand filtration, oil and grease traps and precipitators for gaseous emissions Aina, (1992); Adebayo (2007). So, the indiscriminate discharge of solid, liquid and gaseous wastes into the land and municipal drains remains the only way of disposing off their wastes. Sometimes, farmers dam the flow of this waste water (industrial effluents) and use for irrigation purposes due to advantageous presence of potassium, nitrogen, phosphorus and other essential elements present in them. Niroula (2003)

Although the generation of pharmaceuticals waste in massive quantities has been ongoing for many decades already, it was only in the past decade that scientific studies worldwide have increasingly examined associated effluent and waste generation and their respective impact. Many surveys and studies have confirmed the presence of pharmaceuticals in effluents, municipal wastewaters, surface waters, ground water and, to a lesser extent, drinking water. The ongoing global process of urbanization and population growth has increased the demand for clean water, leading to an

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increase in the volume of effluent to be treated. Bolong *et al.* (2009). There is also a growing demand for new products such as antibiotics, which leads to an increase in new emerging contaminants released into the environment, typically at levels in the nanogram to low microgram per liter range, often without any knowledge of potential related risks to humans and damage to ecosystems. Antibiotics were recently ranked as a major risk group because of their high toxicity to algae and bacteria, even at low concentrations. These risks include an increase in the occurrence of fatal cases of hospital-borne infections with such pathogens that develop resistance towards antibiotic. Hernando *et al.* (2006); Watkinson *et al.* (2009).

Materials and Methods

Sampling area and Collection:

The effluent was collected from the pharmaceutical industry (Bioraj Pharmaceutical Limited located in Ansaru-Ogidi, Ilorin.) in a sterile 4 litre plastic container carried in an ice-chest and stored in a refrigerator until used for the analysis. The sample was collected from the channel offflow into the river and was passed through a sieve in order to avoid debris, paper twigs as well as silt or other small floating materials.

Physico-chemical analysis of the Effluent

The physicochemical properties of the effluent were analyzed as described by Alpha (1989); Aderomoti, (1996). The pH of the wastewater samples was determined at the point of sampling using pH meter (model Jenway 3310). The pH electrode was calibrated using buffers of pH 4.0, 7.0 and 10.0. The electrode was immersed into the waste-water sample and reading was recorded. Temperature was determined using a thermometer, while conductivity was determined using a conductivity meter (Hach model C0150) Partition gravimetric method. APHA, (1992) was used for the analysis of oil and grease. In the method, oil and grease were determined by solvent extraction. The solvent was separated from water and evaporated; the residue remaining was used as a measure of the oil and grease content. The solvent mix of n-hexane and methyl tert-butyl ether (80 % and 20%) respectively was used as the extracting solvent. A 300 ml sample was acidified with 5 ml of HCl. The sample was transferred to a 1-litre separation funnel and shaken for 2 minutes. After the separation of layers, water was drained off and the solvent containing oil content was transferred to a pre weighed 100 ml dish. The solvent was evaporated on a bath. After evaporation the dish was again weighed and the oil and grease content were separated. Total solids were determined by measuring 100 ml of well mixed sample into a dry and pre-weighed evaporating dish at 103-105°C for 1 hour. The content was evaporated to dryness on a water bath; the dish was transferred to an oven and then dried to a constant weight at 105°C. The dish was allowed to cool down in a desiccator and re-weighed. This process of drying, cooling and weighing was continued until a constant weight was obtained. BOD, COD, sulphate, oil and grease were determined using standard methods APHA, (1992). Immediately after collection of sample for metal analysis, the samples were acidified with analar grade of 1.5 ml HNO₃ and stored in the refrigerator at 4°C. Spectra AA Varian 400 plus Atomic Absorption Spectrometer was used in determining the concentration of the metals. The analysis was done in triplicate and the mean values were obtained.

Results and Discussion

The physico-chemical parameters of the effluents investigated are presented in Table 1.

pH: The pH value of these pharmaceutical effluents ranges from 4.60-4.90 with the highest value of 4.90 in sample B. The value is not within permissible limit of 6 – 9 (FEPA, 1991). Hashmi Imran (2005) reported that the pH of waste-water samples is generally towards acidic side. Extremes of pH of waste-water are generally not acceptable as extremes of pH cause problems to survival of aquatic life. It also interferes with the optimum operation of waste-water treatment facilities. The acidic nature of the pharmaceutical effluent is capable of stemming the pH of the respective receiving water bodies thereby, destabilizing fundamental properties such as alkalinity, metal solubility and hardness of water. Wang *et al.* (2002) corroborate the fact that metabolic activities of aquatic organisms are also dependent on the pH values. At low pH most of the metals become soluble and become available and therefore could be hazardous in the environment. At high pH most of the metals become insoluble and accumulate in the sludge and sediments.

Temperature: Increase in temperature of water body will promote chemical reactions in the water. Effects, such as bad odour and taste will result due to non-solubility of gases such as oxygen as reported by Siyanbola *et al.* (2011). Temperature being one of the most important ecological features that controls behavioral characteristics of organisms, solubility of gases and salts in water, the basis of all life functions is a complicated set of biochemical reactions that are influenced by physical factors such as temperature. Disease resistance is also linked to temperature. Increase in temperature also increases the rate of microbial activity (Ram, 2011). In the present study, the temperature of the effluents varies between minimum of 29 °C for the effluents from the pharmaceutical industries and maximum of 32 °C.

Turbidity: Turbidity and transparency are intimately related to hydrological regime of a water body. When there is increase in turbidity, transparency is reduced. In the period of investigation turbidity was observed from 3.00 to 4.50 effluents. The minimum value was observed in sample A, while the maximum value was found in sample B. The

turbidity values were lower than WHO standard of 5 NTU (WHO, 1991). Excessive turbidity in water can cause problem with water purification processes which leads to an increase in treatment cost.

Total dissolved solids (TDS): The total solid concentration in waste effluent represents the colloidal form and dissolved species. The probable reason for the fluctuation of value of total solid and subsequent the value of dissolved solids due to content collision of these colloidal particles. The rate of collision of aggregated process is also influenced by pH of these effluents. As the total dissolved solids (TDS) values increase the conductivity values also increase. The effluent has the values of 168.25 to 197.42mg/L with sample B having the highest and sample A, the lowest for TDS. The TDS values for all the samples were below the maximum permissible limit FEPA, (1991). These suggest that the effluent is capable of causing death of some fish and macro-invertebrates because the oxygen required by these aquatic habitats will be consumed by microorganisms (APHA, (1995).

Chemical oxygen demand (COD): The chemical oxygen demand test (COD) determines the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The COD is a test which is used to measure pollution of domestic and industrial waste. The waste is measure in terms of equality of oxygen required for oxidation of organic matter to produce CO₂ and water. It is a fact that all organic compounds with a few exceptions can be oxidizing agents under the acidic condition. COD test is useful in pin-pointing toxic condition and presence of biological resistant substances.

For COD determination samples were preserved using H₂SO₄ and processed for COD determination after the entire sampling operation was complete. The results are shown in Table 1. As compared to BOD, COD was very high which is normal for such pharmaceutical industries.

The biological oxygen demand (BOD) and chemical oxygen demand (COD) are useful parameters in water quality analysis. BOD and COD are both a function of DO; decrease in DO will lead to increases in BOD and COD values. Table 1 show that the BOD for the effluent samples 1430, 1627 and 1475 mg/l. According to UN Department of Technical Cooperation for Development the maximum permitted BOD content is < 100 to 300 mg/L. while the COD of the samples ranges from 2340 to 3078mg/l respectively. The COD test gives a measure of the non-biodegradable organic materials present in sample. It was observed that in all the effluents collected from different industries, the COD values are very much higher than 4.0 mg/L which is a maximum permissible limit according to NESREA Standard (2010). This test shows the advantage of the COD over the BOD analysis.

Table1: Physico-chemical characterization of pharmaceutical effluent analysed

Parameters	Sample A	Sample B	Sample C
Total alkalinity	1.80	2.20	1.90
Total dissolved solid mg/l	168.25	197.42	175.32
pH	4.60	4.90	4.70
Chemical oxygen demand (COD) mg/l	2340	3078	2678
Chloride	240	300	230
Turbidity (NTU)	3.00	4.50	4.0
Total suspended solid (TSS)	0.91	1.21	1.02
Sulphate	55	85	66
Temperature °C	29	32	30
Biological Oxygen Demand (BOD)mg/l	1430	1627	1475

Chlorides: Chlorides are generally present in natural water. The presence of chloride in the natural water can be attributed to dissolution of salts deposits discharged of effluent from chemical industries, oil well operations, and sewage discharge of effluent from chemical industries among others. In the present study, chloride of pharmaceutical effluent was 230 to 300mg/l. The results indicate maximum chloride content of 300 mg/L in the effluent samples collected from pharmaceutical industries which was above the acceptable limit of 200 mg/L set by WHO, but within the limits of 250 mg/L set by ISI (1991).

Sulphates: Sulphate is one of the major cation occurring in natural water. Sulphate being a stable, highly oxidized, soluble form of sulphur and which is generally present in natural surface and ground waters. Sulphate itself has never been a limiting factor in aquatic systems. The normal levels of sulphate are more than adequate to meet plants need. When water is over loaded with organic waste to point that oxygen is removed then sulphate as an electron acceptor is often used for breakdown of organic matter to produce H₂S and produce rotten egg odour. In the present study the values of sulphate for the effluent samples 55, 85 and 66mg/l for samples A, B and C which are within the permissible limits of 100 mg/L according to the NESREA standards (2010).

Conclusion

The studies performed on the pharmaceutical waste-water treatment plant were evaluated. The experimental data suggests a need to implement common objectives, compatible policies and programs for improvement in the industrial waste water treatment methods. It also suggests a need of consistent, internationally recognized data driven strategy to assess the quality of waste water effluent and generation of international standards for evaluation of contamination levels. The existing situation if mishandled can cause irreparable eco-logical harm in the long-term well masked by short term economic prosperity.

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