ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 2, Issue 1, January 2013

Evaluation of Wastewater from a Refinery Treatment Plant for Agricultural Use

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***Abstract*— Wastewater use for agriculture is on the increase due to the growing world population and the increasing scarcity of good quality water resources. The performance of wastewater from a refinery treatment plant regarding its use for agricultural purpose was evaluated. Samples of the wastewater were collected at points A, B, C and D at specified distances of 10 meters apart. Samples were analyzed for both physical and chemical parameters. The pH value of the results of samples at points A, B, C and D were 7.90, 10.38, 10.27 and 9.92 respectively which are outside the standard range with higher alkalinity. The dissolved oxygen ranges between 7.06 and 13.41 mg/L while the Chloride values ranged between 31.99 and 58.48 mg/L and that of Sodium ranges between 6.50 and 130 mg/L. Ammonia and Nitrate were observed to have a high conductivity in sample at point B. Thus the harmful effect on the environment could be corrected if the wastewater Plant operations supervision is intensified; capable hands (experts) are used coupled with periodic training of personnel.**

Keywords: Environment, farmland, waste, water

I. Introduction

Waste minimization is mandatory for existing industries to eliminate or minimize waste being generated from production techniques [1]. A proper waste analysis at the design stage is therefore necessary. Industries generally ought to look for a simply and less expensive process where this is reduced to the barest level and the quality of waste released into the environment is such that it is not harmful. This is so because waste, even when non-polluting, leads to the depletion of the earth resources including the energy requirements for processing. Thus, recycling waste produced from industries is mandatory for waste minimization process [2].

The increasing demand for environmental protection through regulated environmental standards ought to force industries in Nigeria to re-evaluate the economic impact of the environmental issues and adopt new cost effective approaches to waste management. Management must adopt new attitudes about waste and environmental problems. Waste reduction within the manufacturing industries reduces the various costs of operations; including emission of toxic wastes into the air, water and land and also reduces the amount of raw material inputs in addition to final disposal costs [2].

In order to reduce cost of farm operations, farmers divert sewage effluent from drains to their fields. Thus, endangering the lives of those who are working on the farm as well as the consumers of such farm products which in-turn increases the level of disease outbreak within the various communities.

In many developing urban centers, wastewater is usually a combination of domestic and untreated industrial effluent. The uncontrolled and varied nature of wastewater used for irrigation makes it difficult to define, monitor and control the practice and use of such. There are comprehensive figures of the extent of wastewater used for irrigation but the obtainable estimates indicate that about 900,000 hectares of farmland in developing countries are irrigated with wastewater [3].

Ten percent of the municipal and industrial effluent is treated only to primary level and the rest disposed of or left astray without any treatment. A major proportion of wastewater is confined to the vicinity of cities. It is estimated that about 95,000 acres (32,000 hectares) in Pakistan are irrigated with municipal effluent [4]. Wastewater effluent for irrigation use, could be a valuable source to augment this dwindling water supply, and should not continue to be wasted. Reuse of wastewater effluent could both decrease the disposal of such to the environment and reduce the demand on fresh water supplies [5].

The main reason for wastewater use for agriculture is because of its high plant nutritional content and its all-year-round availability for use by the farmers [6]. It is estimated that the application of 40 cm of sewage effluent can add 100 – 200 kg Nitrogen, 6 – 20 kg Phosphorus and 100 – 250 kg Potassium, eliminating the necessity for artificial fertilizers [7]. The release of nutrient-rich wastewater effluents into receiving rivers results in environmental and human health problems such as eutrophication in water bodies [8].

The use of these wastes in agriculture is seen as an important issue for both soil conservation and residual disposal [9].
The objective of this study was to evaluate the treated wastewater from Kaduna Refinery and Petrochemical Company, Nigeria (KRPC) released to some agricultural farmlands and the results compared with the water quality parameters for agricultural purpose of Food and Agricultural Organization [10], standards of World Health Organization [11], and the Nigerian Standard for Drinking Water Quality [12].

II. Materials and Methods

A. Study Site

Kaduna Refinery and Petrochemical Company, Nigeria (KRPC) occupy a land area of 2.89sq kilometers about 15 kilometers south east of Kaduna city. Its location has an elevation of about 6.5 meter above mean sea level, located on coordinates 10031'23"N and 7026'25"E.

B. Sample Collection

The initial sample of wastewater collected at the point of discharge from KRPC treatment plant was labeled Sample A at a distance of 0 m, the second sample B was collected at a distance of 10 m away from the point of discharge, sample C was collected at a distance of 20 m away from the discharge point while sample D was collected at a distance of 30 m away from the point of discharge. At each point of collection of the wastewater samples, a one liter sterilized container with proper labeling was used. The samples were collected during the dry season for a period of four months (January to April) at the rate of one set of samples per month. The collected samples were placed in an iced box and transported to the laboratory for analysis. This is in accordance with the work of Musa [13].

III. Results and Discussion

Table I below shows the average results for the various samples collected during the period of four months which is the major period of dry season farming. The results obtained were compared with those of [10], WHO [11] and NSDWQ [12].

A. Temperature

There is no set standard for temperature which is known to vary depending on the atmospheric condition in the area. Different organisms (micro and macro) can survive under varying water temperatures. The temperature of the wastewater do not have a direct effect on the growth or the health status of a plant but may affect the condition of the soil or the environment which may lead to high rate of transpiration of water from the plant system or the rate of nitrogen fixing components of the soil. The set standard by World Health Organization and Food and Agricultural Organization for temperature is the ambient temperature. The average temperature for the four samples collected during the study period ranged between 27.1 and 27.6 0C which are within the ambient temperature limits.

B. pH

The standard range of normal pH range for irrigation is 6.5 to 8.5; pH value outside this range would be a nice warning that the water is abnormal in quality. The pH value of the results of samples of point A, B, C and D were 7.90, 10.38, 10.27 and 9.92 respectively which are outside the range with higher alkalinity. Irrigation water with pH outside the normal range may cause a nutritional imbalance or may contain poisonous ions. The municipal wastewater pH result of 7.56 satisfies the pH standard of irrigation water but more is necessary to meet full standard, meaning that away pH, there's such a lot of other analytical parameter in their standards that tells if irrigation water is safe to use. The recommended pH by [10] is in the range of 6.5 – 8.4.

C. Dissolved Oxygen

Dissolved Oxygen in water is an important ingredient of survival for micro-organisms and plants. The value of the dissolved oxygen for the four months of study ranged between 7.06 and 13.41 mg/L. though, no values were available from [10], NSDWQ [12] and WHO [11]. If dissolved oxygen is low in irrigation water as in the wastewater analysis result showed at point C (7.06 mg/L), this indicates that bacteria concentration is high which if such wastewater is used for irrigation purpose, endangers plant growth.

D. Chloride (Cl) and Sodium (Na)

Chloride and Sodium are poisonous ions to both soil and plants [14]. Irrigation water that contains these ions at threshold value can cause plant toxicity problems. The recommended chlorine value for agricultural activities is 0-30 mg/L while that of Sodium is between 0-40 mg/L. from the study carried out, the Chloride values ranged between 31.99 and 58.48 mg/L while that of Sodium ranges between 6.50 and 130 mg/L. It was observed from the analysis carried out for Chloride that none of the areas considered for this study had their values below that recommended while for Sodium only sample A had its value below the recommended value while the others were above the recommended value.

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TABLE I

COMPARISON OF VALUES OBTAINED FROM THE STUDY AREA WITH AVAILABLE WORLD STANDARDS.

		Sample						
Parameters	Unit	A	B	C	D	FAO	NSDWQ	WHO
Temperature	^{0}C	27.1	27.3	27.6	27.5	25 (amb)	25 (amb)	25 (amb)
pH	-	7.9	10.38	10.27	9.92	6.5 – 8.4	6.0 - 8.5	8.5
Conductivity	uS/cm	108	1038	814	665	1000	1000	1000
Turbidity	mg/L	2.3	3.4	4.4	10.5	NS	0.1	0.1
DO_2	mg/L	12.57	13.41	7.06	12.97	NS	NS	NS
COD	mg/L	162	70.4	60	95	NS	NS	NS
BOD	mg/L	70	45.5	29.4	58	NS	NS	NS
Sulfate	mg/L	49	21.5	3	22.5	0 – 20	400	NS
Suspended solid	mg/L	421	358	397	412	NS	500	400
Chloride	mg/L	31.99	58.48	56.98	49.48	4 – 10	250	NS
Ca^{2+}	mg/L	5.62	7.62	9.63	1083	0 – 20	250	250
Chromium	mg/L	0.01	0.18	0.04	0.03	NS	0.05	NS
Magnesium (Mg^{2+})	mg/L	2.44	0.03	1.71	2.44	0 – 5	0.05	0.05
Sodium	mg/L	6.5	130	90.2	49	0 – 40	200	NS
Potassium	mg/L	1.34	6.03	5.36	4.02	0 – 2	200	200
Ammonia	mg/L	0	0	0	0	0 – 5	NS	NS
Zinc	mg/L	0.24	0.27	0.27	0.27	NS	3	NS
Nitrate	mg/L	4	1	2	2.6	0 10	0.2	0.2

A. Total Dissolved Solid

This is a measure of the impurities in a water sample or the total salt concentration of a wastewater sample. It is one of the most important agricultural water quality parameters. Plant growth, crop yield and quality of produce are affected when the total dissolved solid in the irrigation water is above 2000 mg/L. the wastewater from the refinery had the total dissolved solids ranges between 7.06 and 14.41 mg/L which is satisfactory compared to the [10] standard.

The total dissolved solids in the wastewater might have come from the natural dissolution of rocks and minerals along the path of travel of the water. This may have an indirect impact on the wastewater as some of the dissolved materials have the tendency of absolving some of the chemical content released from the treatment plant.

B. Nitrates

This represents the final product of the biochemical oxidation of ammonia. In water, the presence of nitrate is probably due to the presence of nitrogen organic matter and to some extent, of vegetable origin, for only small quantities are naturally present in water. The use of wastewater for irrigation ought to be of immense benefit because the nitrate centered of wastewater might reduce the requirements for commercial fertilizer. Nitrate content may be thought about poisonous if it exceeds 10mg/L [10]. From the refinery wastewater analysis, nitrate values ranged between 1 and 4mg/L which was found to be below the recommended values for [10], WHO [11] and NSDWQ [12]. This is in conformity with the works of Fonseca [15].

C. Ammonia

High ammonia content in wastewater effluent must be strictly controlled as excessive level of it may be poisonous to both animal and plant life. The ammonia content in the various wastewater samples were found not to be present which makes the wastewater usable by farmers for irrigation purpose. Though the maximum permissible limit of ammonia for [10] ranges between 0 and 5 mg/L while those of NSDWQ [12] and WHO [11] were not stated. From the refinery wastewater analysis, zero ammonia content in solution makes the process of nitrogen removal from the wastewater very difficult.

D. Biological Oxygen Demand and Chemical Oxygen Demand

Biological Oxygen Demand (BOD) is usually measured by allowing a sample of wastewater to stand at 200C for four days and calculating the amount of oxygen used up in the work of the oxidation of the organic matter by bacteria. The determined value of the BOD ranges between 29.4 and 70 mg/L. A gradual reduction in the BOD content was observed from point A to D but a very sharp reduction was observed at point C while at Point D a gradual increase was observed. This may be as a result of the introduction of excess wastes from septic tanks from the nearby communities. Chemical Oxygen Demand (COD) is the equivalent amount oxidizing chemical necessary to act on behalf of the bacteria. The COD of this analysis is to know the amount of biodegradable organic matter in wastewater sample.

IV. Conclusions

According to the [10], WHO [11] and NSDWQ [12] the maximum value of Total Dissolved Solids (TDS) irrigation water can contain to maintain plant growth is 500 mg/L. The maximum value obtained from both DO2 and Suspended solid is far below the standard. Since this value is less than the recommended value, the wastewaters are fit for irrigation.

The American Public Health Association [16] recommended that the chloride concentration of groundwater supply necessary to support plant growth is a maximum of 250 mg/L. The chloride concentration obtained from the field work is a maximum of 58.48 mg/L. Clearly, the field values are within the recommended limit and so can be effectively used for irrigation.

Food and Agricultural Organization [10] suggested that the level of stream standard of Dissolved Oxygen necessary for fish farming is not to be less than 2 mg/L. The highest Dissolved Oxygen concentration recorded from the field work is 13.41 mg/L, thus indicating that the waste water cannot be used for fish farming.

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