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MEASUREMENT OF SELECTED PHYSICAL PARAMETERS AND RADIOACTIVITY CONCENTRATION IN WASTEWATER DISCHARGED FROM SOME INDUSTRIAL AREAS IN JOS, PLATEAU STATE - NIGERIA.

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ABSTRACT
This research undertook an assessment of the gross alpha and beta radioactivity as well as some physical parameters of wastewater from some industrial areas in Jos, Plateau state of Nigeria. Samples were collected from the point of disposal of four industrial effluents and two drainage channels from residential areas near those industries. MPC-2000 detector was used for the gross alpha and beta analysis. The results obtained indicate gross alpha activity concentration levels ranging from 0.019±0.01 Bq/L to 66.27±0.01 Bq/L, while gross beta results are in the range of 3.01±0.01 Bq/L to 289.22±0.01 Bq/L. Both results exceeded the maximum permissible limit set by WHO (2006) which is 0.1 Bq/L for gross alpha and 1.0 Bq/L for gross beta radioactivity, except the gross alpha for the first sample location. Similarly, the several results for each of the physical parameters revealed levels of most samples that are beyond the maximum limit recommended by WHO (2006). Chances of these wastewater running into surface water highlights the potential danger posed by these industrial discharges.

Keywords: *Activity Concentration, Gross Alpha, Gross Beta, Pollution, Wastewater, Industrial Effluent*

INTRODUCTION

Water is polluted by the waste of civilization, and this is brought about by the discharge of water borne waste from human activities. Although industrialization is considered vital to the nation's socio economic development as well as its political standing in the international community, and industrial development aims at bringing about positive change in human life, the uncontrolled consumption of natural resources have inadvertently led to environmental degradation, pollution, incurable diseases, poverty and social conflicts (Osinbajo, 2009). In a related research, Bichi and Bello (2013) stated that a significant proportion of the population still relies on these polluted surface and ground waters for drinking, irrigation, fishing and other domestic uses. This is because the improper disposal of untreated industrial wastes in Nigeria has resulted in coloured, murky, odorous and unwholesome surface waters, fish kills and loss of recreational amenities. Hence, with increased urbanization and industrialization, there has been a rapid increase in the municipal wastes, which in turn has intensified the environmental pollution (Akan *et al.*, 2007). While the health effect of ingesting polluted water could be illness, the consequence of prolonged exposure to radioactively polluted water include cancers, toxicity of the kidneys and bearing of children with birth defects. Greater radiation dose increases the chance of developing Leukemia, eye cataracts, Erithemia, hematological depression and incidence of chromosome aberrations.

Though the water supply systems of small, remote communities may differ from those of urban centres quite often base on economic and environmental factors, as stated by Ross *et al.* (2011), the available fresh water in the world is a paltry 2.5 % of the total water resources and the accessible fresh water is an insignificant chunk of the fraction available (Giwa, 2014). Therefore, there has been growing awareness of the need for effective treatment of various effluents before discharging into any public water body. Pollution was observed by Egwuonu *et al.* (2012) to be fast becoming a modern day evil that is raking in some dangerous effects on human health and well-being. Consequently, Water which should be a blessing to life becomes a carrier of poisons, toxicants and pathogens leading to dreadful diseases that cause death (Olaniyi, *et al.*, 2012). In developing countries like Nigeria, lack of safe drinking water is one of the serious threats to human health and as a result of that, rivers, streams, well and borehole waters are often used as alternative to the scarce pipe-borne water for drinking and domestic activities without any treatment (Abdullahi *et al.*, 2016). Pollution may be defined according to Ezeohu and Ugwuishiwu (2011) as the introduction by man into the environment of substances or energy liable to cause hazards to human health, harm to living resources and ecological system, damage to structure or amenity, or interference with legitimate uses of the environment. Wastewater however, is any water that has been adversely affected in quality by anthropogenic influence (Wikipedia, 2016). These effluents released on the land or into water will ultimately leach to ground water and lead to contamination (Bernard and Ogunleye, 2015), and these disposed materials often contain radionuclides.

Alpha and beta emitters are considered the most important with respect to the potential internal radiation exposure to humans (Faanu *et al.*, 2016). Some emitters of gross alpha particles include Uranium and Radium-226 which occur mostly in nature. Emitters of beta particles and photons include Radium-228 and Tritium which are primarily man-made radioactive contaminants associated with operating nuclear power plants, facilities that use radioactive materials for research and manufacturing, or facilities that dispose of radioactive materials (Lesikar, 2006). At high exposure levels, these emitters are believed to cause cancer in humans.

In some cases, the inadvertent release of radioactive materials into the environment creates concern for health and wellbeing of humans and other organisms living in an area. Ogundare and Adekoya (2015) defined radioactive contamination of the environment as any increase in the natural background radiation arising out of human activities involving the use of naturally occurring or artificially produced radioactive substances. This happens majorly due to a loss of control of radioactive materials during the production or use of radio isotopes. Such contamination could be occasional, accidental or continuous. Contamination of the food chain occur as a result of direct deposition of these radionuclides on plant leaves, fruits, tubers and root uptake from contaminated soil or water and animals ingesting contaminated plants, soil or water (Avwiri *et al.*, 2011). Meindinyo and Agbalagba (2012) also noted that these perceived consequences of the consumption of foodstuff and vegetables from these polluted soil and the consumption of untreated and unregulated water and the attending radiological burden has triggered various environmental studies.

Radioecology is the study of the fate and effects of radioactive materials in the environment. An important component of radioecology is concerned with the assessment and prediction of the movement and concentration of these radioactive contaminants in the environment in general, and particularly in food chains that may lead to humans. Primary concern is focused on agricultural pathways through which a radionuclide may enter the human food chain through crop plants or other products of domestic livestock (Mc Graw-Hill, 2007).

MATERIALS AND METHODS

Materials

The materials and reagents used during this research are listed in Table 1.

S/No	Materials	S/No	Materials
1	6 Plastic containers of 2 Litres each	15	Desiccator
2	Beakers	16	Gooch Funnel
3	Hot plates	17	Rubber Adapter
4	Fume Cupboard	18	Filtering Flask
5	Ceramic Dishes	19	Pair of tongs
6	Cotton Wool	20	Evapourating Dish
7	Planchetes	21	Oven
8	MPC 200 Detector	22	5% HNO_3
9	pH Meter	23	Distilled Water
10	Mercury in Glass Thermometer	24	Detergent
11	Magnetic Stirrer	25	Conc. HNO_3
12	Tissue Paper	26	Acetone
13	Glass Fibre Filter Paper	27	Ethanol
14	Electronic Weighing Scale	28	Potassium Chloride

Description of Study Area

The areas under study are the industrial sites of Yakubu Gowon way and Zawan, situated in Jos south of Plateau state, Nigeria, and having a geographical coordinates of 9.917°N and 8.900°E. The major industries in this part of the city include; Grand Cereals and Oil Mills Limited, Coca Cola Company, Nasco Group of Companies, Amo Byng Nigeria Limited, etc. The industrial sites were selected based on their appreciable size and location amongst other criteria.

Sample Collection

One sample each was collected from the terminals of the drainage pipes from within and outside the premises of the industrial site of Yakubu Gowon Road and labeled as Y1 and Y2 respectively. Two other samples were collected at discharge points of industrial sites in Zawan and labeled Z3 and Z4. The last set of samples were collected from residential areas not far from the previous sites and then labeled R5 and R6 respectively. This brings the total number of samples collected to six.

In preparation for sample collection, six plastic containers of 2 liters capacity each were thoroughly washed with non-ionic detergent and soaked inside 5% HNO_3 for 24 hours for effective cleansing, after which they were again rinsed with distilled water. Each used container was first rinsed properly with the water sample in order to minimize possible contamination from the original contents of the container. The sample effluents were then collected from the various outlets, leaving an air space for possible gas expansion and the containers were labeled appropriately. Each of the sample was acidified with concentrated HNO_3 to reduce the pH to 2. The selected samples were prepared for laboratory analysis.

Sample Preparation

At the Laboratory at the Centre for Energy Research and Training Zaria, the samples were agitated. 1000 cm^3 of each sample was poured into a beaker and evapourated on a hot plate at a temperature of 50°C to 60°C in a fume cupboard to a volume of 50 cm^3. It was then transferred into a pre-weighed ceramic dish that was previously cleaned with acetone and cotton wool to avoid contamination of the samples. The samples were further evapourated to dryness using hot plates until a constant weight was obtained; hence, the weight of the residue was deduced after the sample became cold. These dry residues were spread uniformly on a planchet and a few drops of ethanol was added and allowed to dry, after which it was taken for counting.

Sample Analysis

The counting equipment used was the MPC-2000 detector. The sample analysis was carried out using standard method accuracy to American wastewater parameter determination of 1996, and equipment manufacturer specification.

RESULTS AND DISCUSSIONS

Gross Alpha and Beta Results

The results obtained from the analysis of the Gross alpha and beta radioactivity in effluents from selected industrial and residential areas in Jos, plateau state, are displayed in Table 2.

Table 2: Results of Gross Alpha and Beta Radioactivity of Water Samples

Sample Identity	Alpha Activity (Bq/L)	Beta Activity (Bq/L)
Y1	0.019±0.01	3.330±0.01 0.01
Y2	1.020±0.01 0.01	3.010±0.01 0.01
Z3	66.270±0.01 0.01	289.220±0.01 0.01
Z4	1.260±0.01 0.01	5.160±0.01 0.01
R5	1.260±0.01 0.01	4.010±0.01 0.01
R6	1.490±0.01 0.01	4.290±0.01 0.01
Average	11.890±0.01 0.01	51.500±0.01 0.01

Water samples from the study area exhibit gross alpha activity concentration values which range from 0.019 Bq/L near Yakubu Gowon road to 66.270 Bq/L at Zawan and having a calculated average value of 11.890 Bq/L as shown in Table 2. This implies a high presence of radionuclide in those effluents and could constitute radioactive hazard to people around there.

The gross beta activity concentration ranges from 3.010 Bq/L at the second sample site near Yakubu Gowon road to 289.220 Bq/L at the first sample point of Zawan with an average value of 51.500 Bq/L. The chart in Figure 2 compares the activity concentration result for alpha with the WHO limit for drinking water.

The measured values of gross alpha activity concentration for the sample points were found to be higher than the WHO (2006) recommended level except the result of Y1 sample point which is 0.019 Bq/L. In the case of gross beta radioactivity, test results showed that the activity concentrations of all the water samples are higher than the WHO limit. The average gross alpha activity concentration in the water sample is 11890% higher than the WHO limit of 0.1Bq/L, while the mean gross beta activity concentration is 5150% higher than the WHO recommended level of 1.0Bq/L.

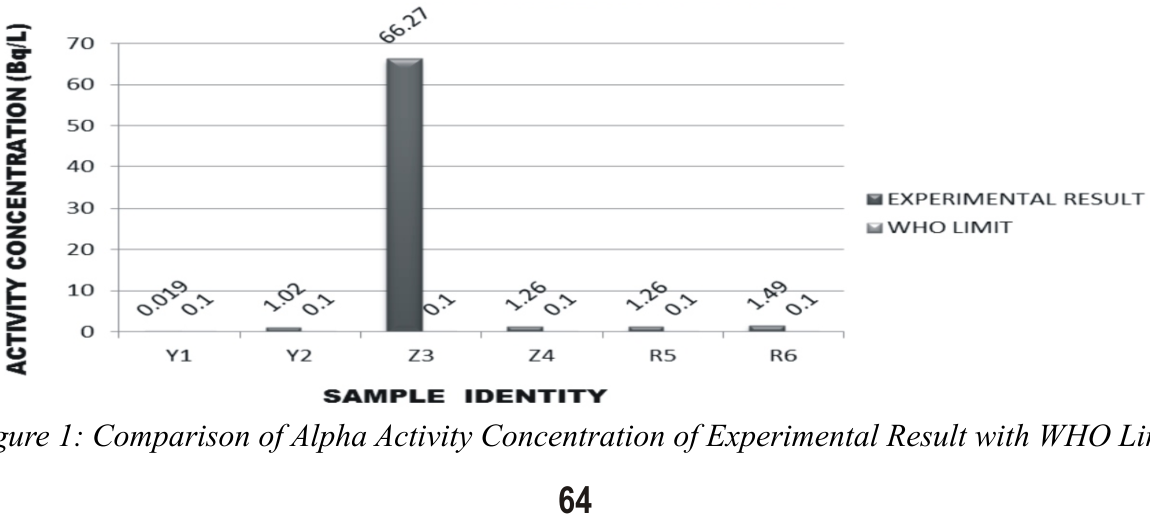

Figure 1: Comparison of Alpha Activity Concentration of Experimental Result with WHO Limit

Figure 1 above reveals that alpha activity concentration for Z3 was higher than the WHO (2006) maximum contaminant level of 0.1 Bq/L for water by 66270%, the results from four other sample points are still slightly higher, while that from Y1 falls safely below the contaminant limit.

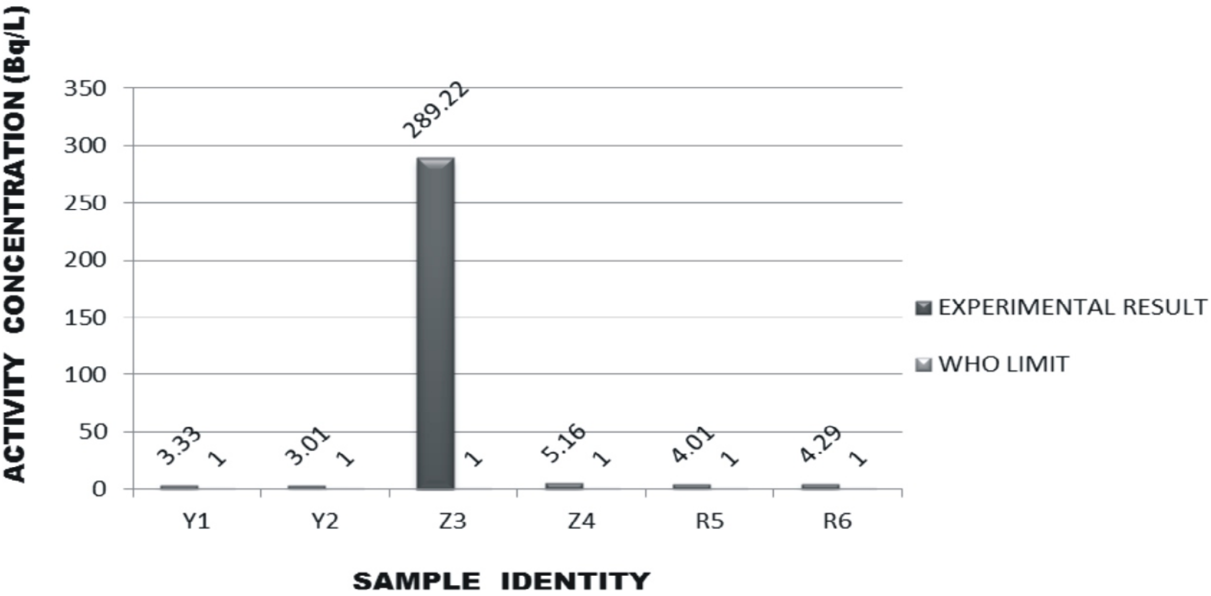

Figure 2: Comparison of Beta Activity Concentration of Experimental Result with WHO Limit

Similarly, the beta activity concentration chart shows that though all the sample points have higher activities than the WHO (2006) maximum contaminant limit of 1 Bq/L, Z3 sample point particularly exhibits the highest contamination level, as revealed in figure 3 to be 28922% higher than the set limit..

The Physical Parameters

The results of the selected physical parameters measured were also presented in Table 3.
Table 3: Results of the physical parameters of the samples

Sample Identity	pH	Electrical Conductivity (s/cm)	Total Dissolved Solid (mg/L)	Temperature (^oC)
Y1	8.46	729	366	27.4
Y2	10.99	3999	2000	27.7
Z4	5.86	51	25	27.5
R5	8.58	14	7	28.0
R6	4.32	2872	1434	27.5
WHO LIMIT	6.50 -8.00	2250	2000	30.0

Sample Z3 has high density and therefore the pH meter could not be used effectively on it, so it was excluded in the Table 3. Figure 3 shows that the pH values for all the sample points fall outside the range of allowable level by WHO (2006), which is 6.5 -8. While effluents from Z4 and R6 sample points have lower pH values, samples from all the other locations have higher pH values. Low pH increases the corrosivity of materials, and generally, pH outside permissible level adversely affects the availability of plant nutrients, heavy metal concentrations, growth of Algae and micro organisms (Akan *et al,* 2007).

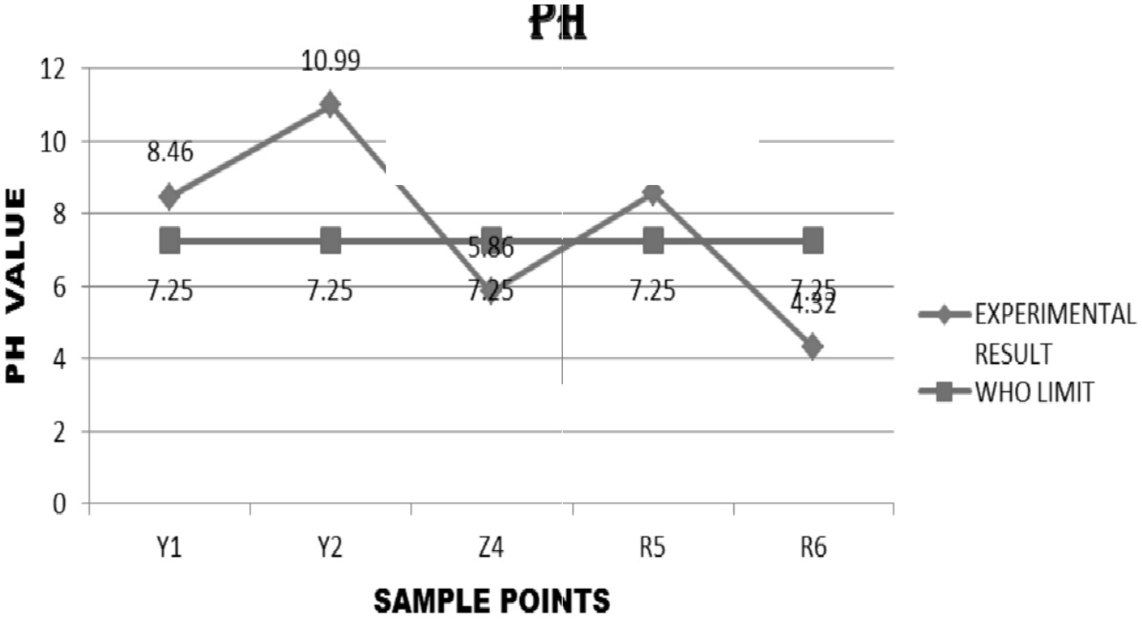

Figure 3: Comparison of Experimental Result for pH with WHO (2006) Limit

The Electrical Conductivity values for the wastewater samples from Y1, Z4 and R5 sample points are within safe limit, but that of Y2 and R6 sample locations are higher than the WHO (2006) limit. This can be inferred from Figure 4. The electrical conductivity of water is directly linked to the concentration of ions and their mobility. These ions in water act as electrolytes and conduct electricity.

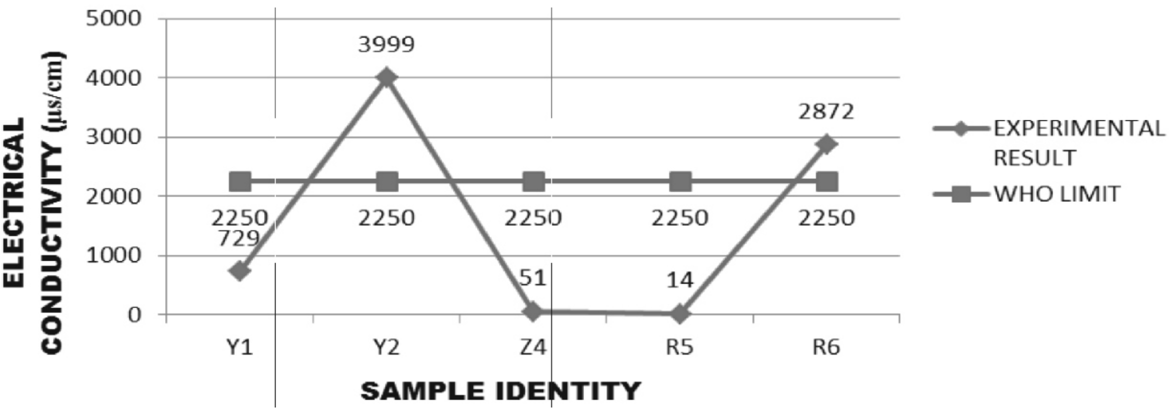

Figure 4: Comparison of Experimental Result for Electrical Conductivity with WHO (2006) Limit

It was observed from the line graph of Figure 5 that none of the sample locations have total dissolved solid value higher than the maximum permissible limit, which range from 320mg/L to 2000 mg/L. The peak value at Y2 is exactly 2000mg/L while Y1 and R6 are also within the normal range. However, the fact that the samples from Z4 and R5 locations have values lower than the normal range shows that those samples are relatively clear. High TDS value increases the salinity of water and this could render it unhealthy for drinking or irrigation. Consumption of water with high TDS has been reported to cause disorders of alimentary canals, respiratory system, nervous system coronary system beside causing miscarriage and cancer (Reddy and Subba, 2001) as cited in (Bernard and Ogunleye, 2015).

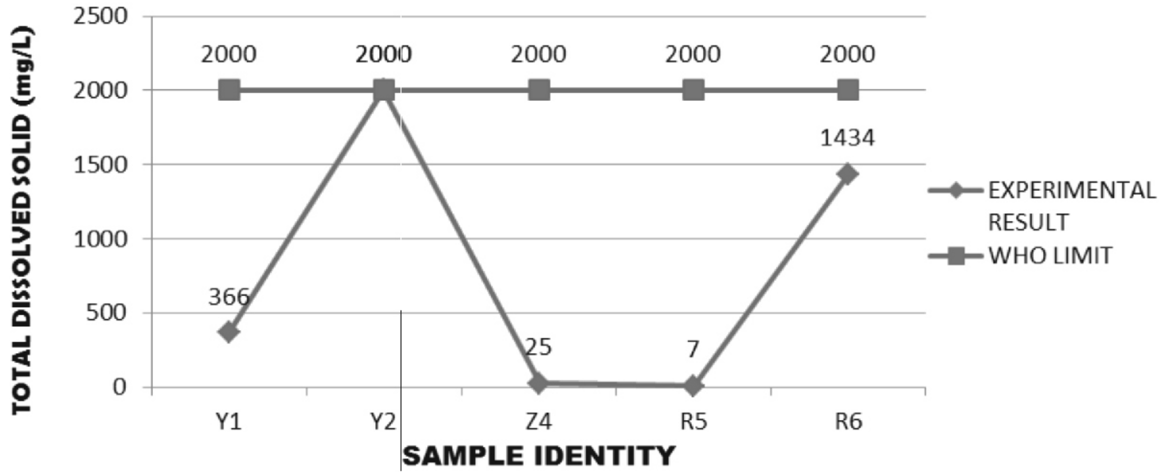

Figure 5: Comparison of Experimental Result for Total Dissolved Solid with WHO Limit

Finally, the measured temperatures of all the five sample locations fall below the expected temperature of 30°C in WHO (2006) guideline for irrigation water. This was expected especially as the temperature of Jos is usually lower than those of most towns in Nigeria.

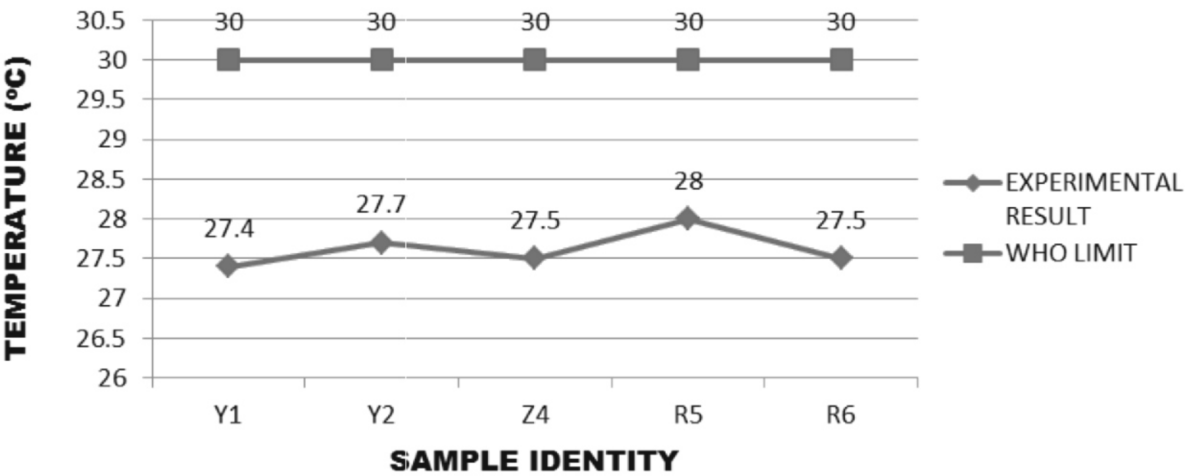

Figure 6: Comparison of Experimental Result for sample Temperature with WHO Limit

CONCLUSION

The results of this study shows shows that the gross alpha activity concentration of all the sample point were higher than the WHO (2006) limit of0.1 Bq/L except that of Y1 sample point. The gross beta activity concentration for all the sample points were also discovered to be higher than the WHO (2006) maximum limit of 1Bq/L. Similarly, Results of some analysed physical parameters show that the pH of Z4 and R6 sample locations were lower than the WHO (2006) normal recommended range of 6.5 to 8.0, while that of Y1, Y2 and R5 were found to be higher than normal. The electrical conductivity result shows that Y2 and R6 samples conduct higher than the approved limit of 2250 s/cm whereas those of Y1, Z4 and R5 have lower values. For total dissolved solid, values from all the sample points were lower than the WHO (2006) limit of 2000 mg/L except for Y2 sample point which is exactly equal in magnitude to the limit. Finally, all recorded temperature were less than 30 °C.

RECOMMENDATIONS

Based on the potential danger posed by the continuous discharge of these industrial wastewater into the municipal environment, the following recommendations were made:

- An environmental and health impact assessment should be carried out to ascertain the extent of damage being caused by these effluents.
- Regular monitoring of land, water and plants for pollution from industrial effluents by the appropriate government agencies.
- Strict legislations should be enacted to enforce standard practice of waste treatment Before disposal into the environment.

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