The effect of pH in the Removal of PAH by using Sodium Persulphate to remediate petroleum products contaminated Ground Water

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DOI: 10.29322/IJSRP.10.03.2020.p9965
http://dx.doi.org/10.29322/IJSRP.10.03.2020.p9965

Abstract- A study to determine the effect of pH on the removal of polycyclic aromatic hydrocarbon (PAH) from ground water contaminated with petroleum product samples was undertaken. This study enabled the use of chemical oxidants to remediate PAH in contaminated ground water.

Observation showed that the rate of contaminant removal was highest in alkaline environment.

High pH values favoured higher contaminant removal as transformer oil had 91.3 diesels, 86.7 and crude oil, 83.10 percentage removal efficiencies respectively. The trend of the results obtained in this study revealed that the rate of degradation increased with increase in pH values.

Index Terms- Groundwater, Polycyclic aromatic hydrocarbon(PAH), Petroleum Products, Alkalinity and chemical oxidation.

I. Introduction

pH of a solution is a measure of the concentration of hydrogen ions or a measure of alkalinity in the solution. It is the negative logarithm of the hydrogen ion concentration to the base 10. **(**pH = -log $[H^+]$[5])

Acidity and alkalinity of substances are measured using a scale of numbers from 0 to 14 and this is called the pH scale. Any solution with a pH value of 7 is said to be neutral while that with a pH value less than 7 is acidic. A solution with a pH value more than 7 is alkaline. [9]

Acidity increases with decreasing pH value while alkalinity increases with increasing pH values. At neutrality the pH value is 7. [8, 16]

Indicators are weak organic acids or bases which will produce different colours in solution according to the hydrogen ion (H^+) concentration in that solution. The instrument used to measure pH is called the pH meter. It consists of two electrodes, a glass electrode and a reference electrode which measures the voltage difference between two electrodes and gives a pH reading. The meter is usually connected to a strip-chart recorder.

Concentration of hydroxide ions $[OH^-]$ is inversely proportional to the hydrogen ions $[H^+]$ concentration. A pH measurement of both indicates alkalinity and acidity of a solution.

Other methods of measuring pH values include series of successive colour changes in an indicator and comparing the colour obtained with that of the standards given. The pH of a solution is only measured accurately by using a pH meter. Strong acids and strong alkalis have pH values at the extremes of pH scale while weak acids and alkalis have pH values close to 7.

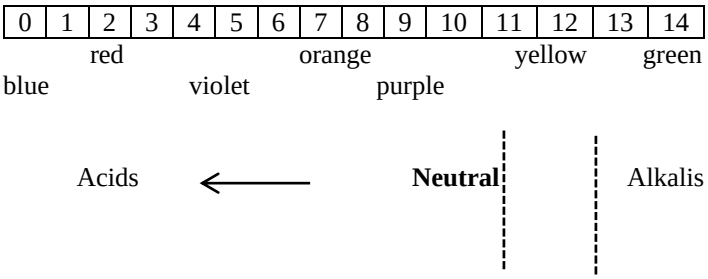

Fig 2. **pH scale showing range and colour changes of indicators.** [15, 17]

The progress of many chemical reactions is often dependent on the pH of the solution in which they take place. It is therefore necessary to note or control the pH of the reaction medium.[13, 12]

Ground water is universally the main source of portable water and also very important for both agricultural and industrial purposes. [3]

It is very imperative that ground water must be properly maintained and preserved for general use. [4, 5]

Pollution of this vital natural resource poses a great danger to man and the environment as it affects useful lands sites and negatively affects the ecosystem causing the destruction of fauna and flora. [8, 17]

Taking in contaminated groundwater can result in serious health risks such as dysentery, cancer hepatitis and cholera food poisoning and general epidemics. Other long term effects could be infertility in man, animals and soil. Petroleum products, if not properly handled could leak into the environment from various storage tanks which may eventually lead to pollution of the ground water. [11] Wrong use of manures and chemical fertilizers could also cause percolation and eventual seepage into the soil. Salts and chemicals from effluents could find their ways through the soil into ground water. Some of them have immediate effects while others have long time hazardous effects.[3, 17 and 12]

This study is therefore aimed at destroying or reducing perceived contaminants to less harmful substances.[13, 14]

II. Methodology

This study involved setting up laboratory tests to determine the effect of pH on the removal of (PAH) using sodium persulphate from petroleum products contaminated ground water.

The population of study is contaminated ground water contaminated with diesel, transformer oil and crude oil. All faced the same treatment with the oxidant. They were a homogenous population. Contaminated ground water was simulated in the laboratory in order to monitor the efficiency of the oxidant to degrade the perceived contaminant.

III. Sodium Persulphate Preparation

0.34g, 1.98g, 8.57g, 19.7g, 30.68g, of solid sodium per sulphate were prepared and added to 100ml of double de- ionized water. This has been demonstrated by Tsai *et al.*, (2009).

3.1 Sample collection and treatment

Contaminated water samples were prepared by adding hydrocarbon products (transformer oil obtained from Nigeco Nig Ltd, diesel and crude oil obtained from the Port Harcourt Refinery) into double deionized water in 4-litre plastic buckets. The mixtures were vigorously shaken for 30minutes. Ameliorating solution Di-Chloro Methane (DCM) of 5.0ml was also added to 30ml of each of the saturated samples in Erlenmayer flask. They were shaken vigorously after an initial pH readings of 7.2 was taken.

3.2. Analysis for pH effect

pH of the contaminated water were adjusted to values of 3.0, 4.5, 6.0, 7.5, 8.0, 9.5, 11.0 and 12.5 using 0.1m Hcl and 0.1m NaOH reagents. Exactly 10ml of the oxidants each were added. The mixture was thoroughly shaken for 1hr (60mins) at 29^{o}C. The mixture was then separated using separating funnel and the concentration of PAH was determined using GC –FID.

IV. Results

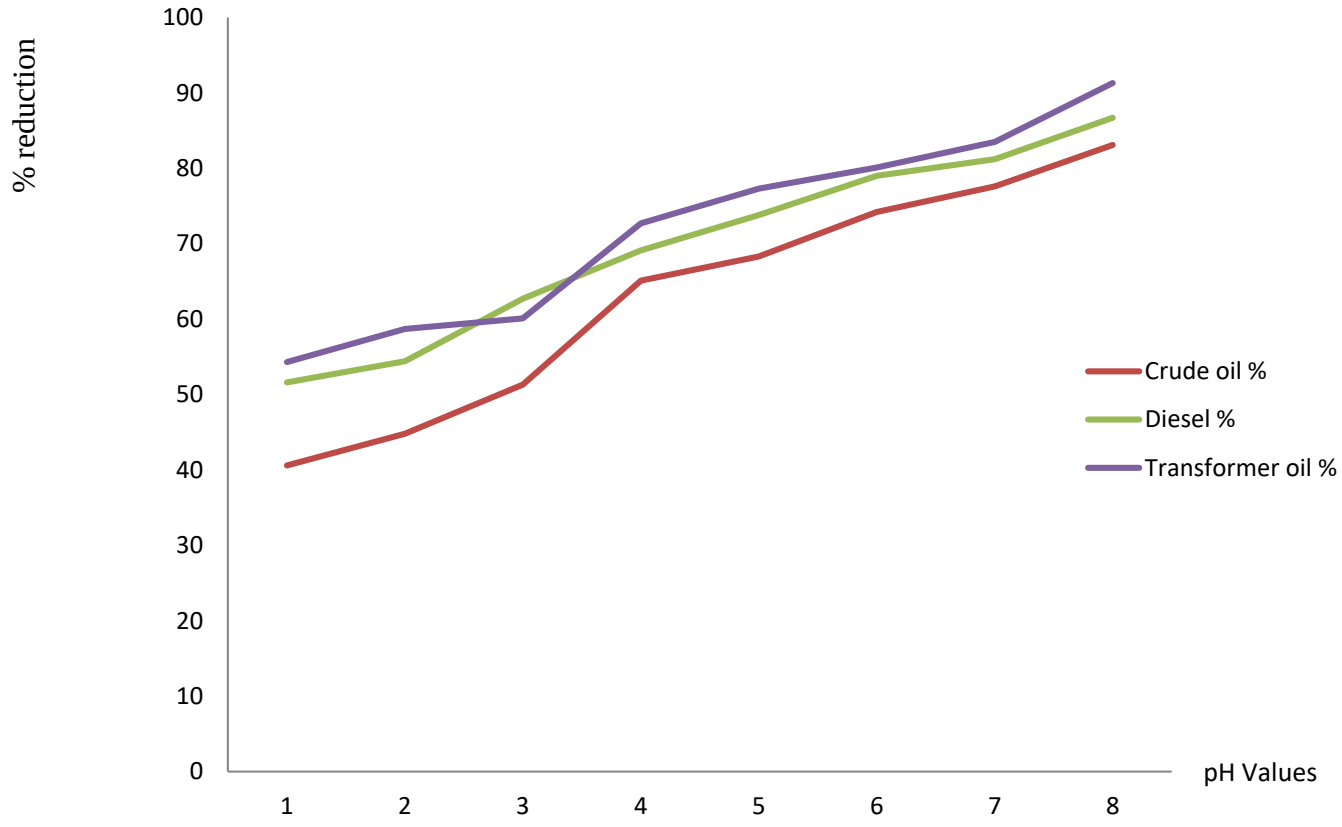

Fig. 1. % removal of PAH from contaminated ground water using sodium per sulphate.

V. Discussions

The high pH of 12.5 recorded higher degradation of PAH in all the petroleum products. Percentage removal stood at crude oil, 83.10%, diesel 86.70% and transformer 91.30%. At pH of 7.5 which could be regarded as neutrality, percentage degradation of crude oil was 65.10%, diesel 69.10% and transformer oil 72.70%. Degradation in the acidic medium recorded very low values of 40.60% for crude oil, diesel 51.60% transformer oil 54.30%.

The smallest value of degradation was obtained at acidic pH level of 3.0. Reason for above results is not farfetched as crude oil contains all the parts of petroleum unrefined. Much of the

pollutants were found in crude oil and less diesel and transformer oil respectively.

VI. Conclusion

From results obtained in this study, it is evident that the alkaline environment is a better medium for the remediation of contaminants from ground water contaminated with petroleum products. Alkalinity favours easy removal of contaminants from the environment than the neutral and acidic type. This is followed by the neutral environment in which degradation of the petroleum products were at 65%, for crude oil, 69% for diesel and 72% for transformer oil. The study showed that acidic environment posed resistance to degradation when sodium persulphate is used as oxidant. In all cases, the three petroleum products had low percentage degradation values of 40 for crude oil, 51.6 for diesel and 54.3 for transformer oil respectively. It is therefore deduced from this study that, with pH being acidic as in most contaminated ground water, chemical oxidation using persulphate oxidants is not a favourable option for remediating impacted sites, expect pH of the site is made highly alkaline.

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