EFFECT OF AGROCHEMICAL USE ON WATER QUALITY OF A STREAM FLOWING THROUGH THE FARM SETTLEMENT AT EWEJE, ODEDA LOCAL GOVERNMENT AREA OGUN STATE NIGERIA

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Abstract
The study examined the impact of agrochemicals (chemical fertilizers, herbicides and pesticides) used in crop production on the quality of surface water of a stream flowing through a farm settlement. Water samples were collected at four points along the stream, before the farm (BF), within the farm 1 (WF1), within the farm 2 (WF2) and after the farm (AF) on monthly basis in a 3-month period. Collected samples were analyzed using standard methods for parameters such as pH, Electrical conductivity (EC), COD, DO, Turbidity, Total Hardness, Nitrates and Phosphates and also for some agrochemicals active ingredients such as Glyphosphate, Atrazine, Cypermethrin, Mancozeb, Paraquat and Cyfluthrin. The results for the parameters listed above ranged from 5.72 - 6.75, 23.50 - 37.50 µScm-1, 1.38 - 13.72 mg/L, 3.63 - 23.48 mg/L, 18.45 – 10 mg/L, 5.63 - 37.5 NTU, 72.11 - 106.50 mg/L, 5.5 - 18.43 mg/L, 7.5 - 16.64 mg/L, 0.19 - 0.37 mg/L, 0.04 - 0.13 mg/L, 0.11 - 0.21 mg/L, 0.03 - 0.08 mg/L, 0.04 - 0.11mg/L, 0.19 - 0.3mg/L respectively. The results of the ANOVA and Principal Component Analysis (PCA) was significant ($p<0.05$) for pH, EC, Total hardness, Phosphate, Glyphosphate, Atrazine and Cyfluthrin between the locations and between months for all parameters except for Phosphate. Agricultural activities in the area polluted the surface water flowing through it.

Keywords: Surface Water Quality; Agrochemicals; Farm Settlement; Crop Production; Pollution.

1.0 INTRODUCTION

Higher demand for food production has led to increase in search of alternative ways of achieving it, and among different ways available is steady increase in the use of agrochemicals (chemical fertilizers and pesticides) for sustainably higher yields. However, the increases in the use of chemicals in food production poses serious threat to the quality of water, used for irrigation and drinking by the villagers, as the runoff of these chemicals pollute it. Excessive nutrients concentrations not used by the crop plants end up being washed into adjacent aquatic systems where they may cause problems such as eutrophication (Altieri and Anderson, 1992; Altieri and Rosset, 1996).

The application of pesticide and herbicides for the control of wide variety of insectivorous, herbaceous pests and green leaves since chemical age, has contributed enormously to the success of Green Revolution program globally, ensured clean fresh produce free of insect marks but with some noticeable pollution effects on ecosystem and human health (FAO, 1993).

Long-term continued exposure of agrochemicals to aquatic creatures due to increased applications, which may vary in degree of persistence even when the environmental concentrations are not acutely toxic, is not sustainable and can become critical (Magnusson *et al.* 2013). This called for thorough investigations into the impact of continuous application of agrochemicals in farmland settlements on water quality downstream the farm settlement at Eweje.

This study, therefore, aimed at investigating the effects of agrochemical use on water quality of a flowing stream through Eweje farm settlement in Odeda Local government area in Abeokuta, Ogun state, Nigeria.

2.0 MATERIALS AND METHOD

2.1 *Study Area*

This research was carried out on a farm settlement at Eweje**,** Odeda Local Government Area located on the outskirts of Abeokuta in Ogun State, Southwestern Nigeria on the longitude 3˚30 30.678˝and latitude 7˚13 37.699˝ as shown in Figure 1. The study area is characterized by a tropical climate with distinct wet and dry seasons. The wet season is associated with the relative prevalence of the Moist Maritime Southerly Monsoon from the Atlantic Ocean, while the dry season is predicated by the Continental North Easterly harmattan winds from the Sahara Desert. The area is located within a region characterized by a bimodal rainfall pattern. Annual rainfall ranges between 1400 and 1500 mm in Abeokuta and environs. The region is characterized by relatively high temperature with a mean annual air temperature being about 30°C. Humidity ranges annually between 37% and 85% (Ufoegbune and Fabiyi, 2016).

The farm settlement uses agrochemicals (fertilizers, herbicides and pesticides) in the production of its crops, where crops such as maize, tomato, cassava, garden egg are being produced while livestock rearing and fish farming are also major agricultural practices being performed in the area. Nitrogenous and phosphorus fertilizers are the commonly used chemical fertilizers in the area while agrochemicals with active ingredients such as Atrazine, Paraquat dichloride, Mancozeb, Glyphosphate, Cypermethrin and Cyfluthrin are widely used by farmers in the area.

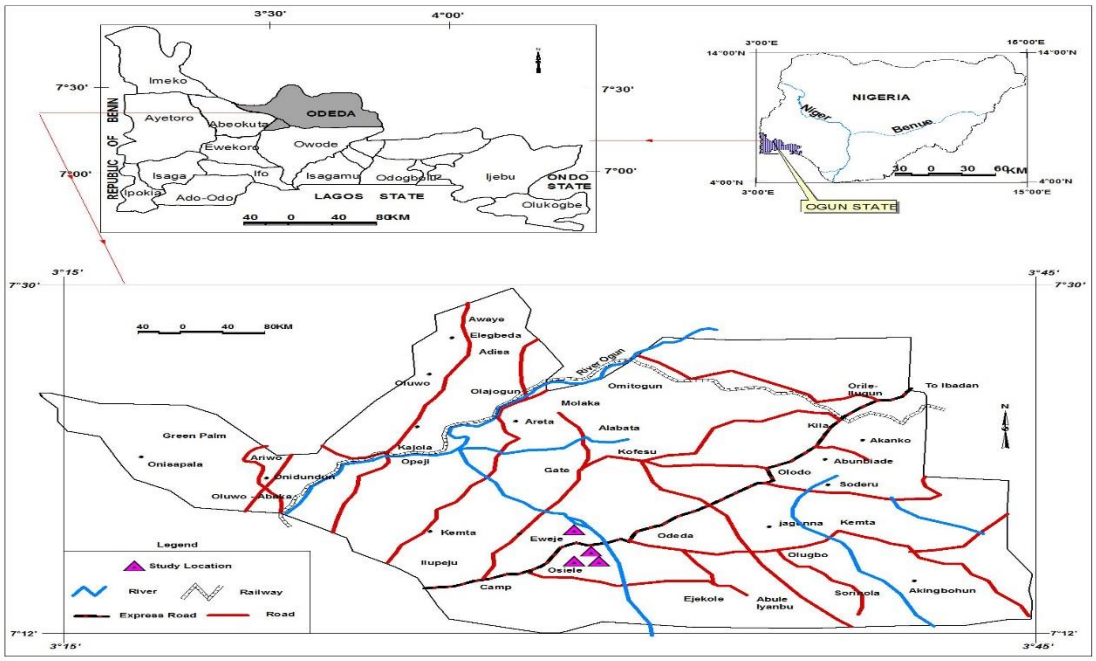


Figure 1: Maps of Nigeria, Ogun state and Odeda local government area

2.2 Collection of Water Samples

A total of twelve water samples were collected from a stream flowing through the study area for a period of three months between 20th of July 2017 to 18th of September 2017 at a rate of four samples per month; collected at the first point upstream before the farm (BF) (longitude 3˚29 46.008˝ and latitude 7˚14 10.829˝) where no agricultural activity takes place, the second site is located at a distance 0.96km away from the first site, located within the farm {WF1) (longitude 3˚30 16.476˝ and latitude 7˚14 6.138˝)where crops such as pepper and garden egg are grown around the location with the use of chemical fertilizers and pesticides. The third site is located at a distance 0.6km away from the second site (WF2) (longitude 3˚30 31.374˝ and latitude 7˚13 53.364˝) where crops such as maize and cassava are grown, and fish farming is also practiced at

various locations around the area where the water used for this purpose is supplied by the flowing stream. The fourth is situated after the farm at a distance 0.45km away from all farming activities (AF) (longitude 3˚30 40.08˝ and latitude 7˚13 42.133˝). The water samples were collected in 0.5 liters plastic containers and immediately taken to the lab to test for the physico-chemical properties and pesticide concentration. All laboratory procedures were carried out following the American Standards for Testing Materials (ASTM) standards manual of water and environmental technology method D1385-88 for natural and treated water.

2.3 Statistical Analysis of the Result

The results were statistically analyzed using two statistical analysis tool, Analysis of Variance (ANOVA) and Principal Component Analysis (PCA), the ANOVA is used to determine if there is any statistically significant differences between the means of three or more independent group, it compares the means of the groups and determine whether any of those means are statistically significantly different from each other, the one way ANOVA is an omnibus test statistic and will not tell which groups were statistically significant from each other, a Post Hoc test is used to determine this. PCA detects similarities and differences in water quality while pinpointing fewer important parameters that explain a high variability in samples. The technique is therefore useful in describing water quality with multiple variables, the generated principal components (PC) are uncorrelated new variables, obtained by multiplying the original correlated variables with the eigenvector loadings. The principal component (PCs) can be expressed as:

$$zij = ai1x1j + ai2x2j + ai3x3j + \ldots + aimxmj \quad (1)$$

Where, z is the component score, a is the component loading, x is the measured value of the variable, i is the component number, j is the sample number, and m is the total number of variables. As a common practice, PCs with eigenvalues greater than one were retained since they explained the highest total variability in water quality.

3.0 RESULTS AND DISCUSSION

The laboratory physico-chemical results of analyzed water from the four collecting points at the study area are presented in Table 1.

3.1 pH value

For the three months, averaged pH values ranged significantly ($p \leq 0.05$) from 5.715 to 6.745, the lowest value was recorded at the location WF2 in the month of September while the highest value was recorded at the location WF1 in the month of August. Most of the pH values recorded in the locations were within WHO (1998) limits for drinking water with the exception of AF, and WF1 and WF2 for the 3 months and September respectively which only satisfied FAO (1993) permissible limit for irrigation water. Generally, pH concentrations increase as a result of the photosynthetic algae activities that consume carbon dioxide dissolved in water (Gandaseca *et al.*, 2011) while the low values recorded in September might be as a result of the higher amount of rainfall generally experienced in September in the region.

3.2 Electrical conductivity

Electrical conductivity (EC) measures water's capacity for carrying electrical current and related directly with ionized substances in water (Lata *et al.,* 2014). Electrical conductivity ranged significantly from 23.5µScm^{-1} to 37.5µScm^{-1} ($p \leq 0.05$) among the different locations for the three months; the highest value was recorded in the month of September at WF2 while the lowest value was recorded in August at WF1. Electrical conductivity values recorded in all the locations

were within the recommended limits for drinking and irrigation water according to WHO (1998) and FAO (1993).

3.3 COD

COD ranged from 1.375 mg/L to 13.715 mg/L for the three months, the highest and lowest values were recorded at BF and WF1 in the months of August and July respectively. The COD varied significantly ($p \leq 0.05$) between the months but did not vary significantly within the locations. Since COD values observed across the sampling locations were very low compared to 255 mg/l reported as a standard value for domestic, indicating absence of biologically resistant organic substances (Awomeso *et al.,* 2010) in the stream in the study area. It implies that the agrochemicals used in the study area have low impact on the quality of the stream running through the farm.

Table 1: Physicochemical Parameters of Water Samples for the Three Months

PARAMETERS	MONTH	BF	WF1	WF2	AF	WHO (Portable)	FAO (Irrigation)
PH Value	July	6.60	6.72	6.66	6.36		
	August	6.65	6.74	6.68	6.41	6.5-8.5	6.0-8.5
	Sept.	6.54	6.40	5.71	6.30		
Conductivity (μScm^{-1})	July	31.5	25.00	30.5	26.5		
	August	29.00	23.50	28.50	24.50	750	3000
	Sept.	35.00	32.00	37.50	31.50		
COD (mg/l)	July	3.54	1.37	2.13	4.63		
	August	13.71	7.74	9.50	6.64	---------	--------
	Sept.	6.26	5.89	8.41	6.11		
DO(mg/l)	July	7.47	3.62	5.90	8.90		
	August	23.47	12.56	17.86	10.50	5.0-7.0	>4.0
	Sept.	6.34	5.18	6.20	5.11		
Alkalinity (mg/l)	July	101	72.5	61	76		
	August	38.02	26.03	34.00	18.45	120	--------
	Sept.	59.74	39.74	76.02	59.19		
Turbidity (NTU)	July	21	37.5	27.5	32.5		
	August	11.10	5.63	19.03	28.13	5.0	--------
	Sept.	20.20	13.19	28.14	19.27		
Total Hardness (mg/l)	July	86	106.5	95	99		
	August	80.48		89.43	72.11	300	-------
	Sept.	89.70	91.36	77.48	82.24		
Nitrate (mg/l)	July	5.5	8.5	7.0	7.5		
	August	13.70	18.43	15.89	9.88	45	50
	Sept.	5.97	6.32	5.82	6.53		
Phosphorus (mg/l)	July	8.5	15.5	12.5	7.5		
	August	9.13	16.64	13.48	7.77	0.1	2
	Sept.	8.55	10.05	8.43	10.47		

3.4 Dissolved Oxygen Content

DO ranged from 3.625mg/L to 23.475mg/L for the three months, the highest and lowest values were recorded at BF and WF1 in August and July respectively. DO values recorded was found to be above the WHO (1998) recommended limit for drinking water in most of the locations and within FAO (1993) permissible limit for irrigation water, and they varied significantly ($p \leq 0.05$) between the months but not significant within the locations. Higher dissolved oxygen indicates the presence of high oxygen content in the water samples. This could be the reason for highest value of COD observed in August, indicating highest amount of oxygen that can be consumed by reactions in a measured solution (Awomeso *et al.,* 2010).

3.5 Alkalinity

Alkalinity ranged from 18.45 mg/L to 101 mg/L for the three months, the highest and lowest values were recorded at BF and AF in July and August respectively. Alkalinity values recorded was found to be within the WHO (1998) recommended limit for drinking water in all the locations and the values varied significantly ($p \leq 0.05$) between the months and within the locations.

3.6 Turbidity

Turbidity ranged from 5.63 NTU to 37.5 NTU for the three months, the highest and lowest values were recorded at WF1 in the months of July and August respectively. Turbidity values recorded was found to be above the WHO (1998) recommended limit for drinking water in all the locations with significant variation ($p \leq 0.05$) recorded between the months but not between the locations. Turbidity results from the presence of suspended particles such as silt, plankton, clay, organic matter, and other microscopic or decomposers organisms; and the clarity of water generally decreases as a result of the presence of these suspended particles deposited in the water. Therefore, the murkier water in general could be ascribed to the higher amount of sediments, which could be from runoff arising from heavy rainfall. The higher turbidity values observed in the study area was in agreement with the submission of Orebiyi *et al. (2010)* for the study area, Abeokuta.

3.7 Total hardness

Total hardness ranged from 72.11 mg/L to 106.5 mg/L for the three months, the highest and lowest values were recorded in the months of July and August at WF1 and AF respectively. Total Hardness values recorded was also found to be within the WHO (1998) recommended limit for drinking water in all the locations and the values varied significantly ($p \leq 0.05$) between the months and the locations, Generally, the total hardness is a function of the geology of the area which the surface water is associated. Hardness has no known adverse influences on health; nevertheless, some evidence has been given to point out its impact on heart diseases (Wright, 2010). The total hardness also comes from the presence of inorganic salts such as calcium and magnesium which are found in chemical fertilizers.

3.8 Nitrates Content

Nitrate ranged from 5.5mg/L to 18.43mg/L for the three months, the highest value was recorded in the month of August at WF1 while the lowest value was recorded in July at BF. This observation could be as a result of non-farming activities at BF and short break in rainfall usually observed in August thereby reducing the dilution process and increasing the concentration of Nitrates at WF1. Nitrates values recorded was found to be within the WHO (1998) and FAO (1993) recommended limits for drinking and irrigation water respectively in all the locations, and the values varied significantly ($p \leq 0.05$) between the months but not within the locations. Nitrate is

a naturally occurring form of nitrogen which is very mobile in water. Surface water which is high in nitrate levels is potentially harmful to human (Methemoglobinemia, cancer etc.) and animal health (Lata *et al.,* 2014; Awomeso *et al.,* 2010; Orebiyi *et al.,* 2010).

3.9 Phosphate Content

Phosphorus as phosphate ranged from 7.5mg/L to 16.64mg/L for the three months, the highest value was recorded in the month of August at WF1 while the lowest value was recorded in July at AF, this might be due to the fact that August corresponds to the middle of the planting period during which more fertilizers were applied

Phosphates values recorded in all the locations was found to be above the WHO (1998) recommended limit for drinking water while the values vary significantly ($p \leq 0.05$) within the locations but not within the months. High concentrations of phosphates are generally indication of the pollution associated with eutrophication condition in the surrounding surface water body (WHO, 1998). Moreover, domestic effluents which particularly contain detergents, fertilizer runoff, and industrial wastewater are the main reasons of high phosphate levels in surface waters (Sharpley et al., 2000; Al-Badaii *et al.,* 2013).

This could also form carcinogens during water chlorination if treated for drinking water which becomes health hazard to human and enhances the C*yanobacteria Pf*iesteria blooms that kill fish (Ladapo and Akangbe, 2014). The results of the analyzed pesticide contents found within the farm and its environs are presented in Table 2.

Table 2: The pesticide concentration levels within farm and its environs

PARAMETERS (mg/l)	MONTH	BF	WF1	WF2	AF	WHO
	July	0.29	0.37	0.33	0.26	
Glyphosphate	August	0.30	0.24	0.27	0.19	-------
	Sept.	0.30	0.25	0.28	0.23	
	July	0.09	0.13	0.10	0.06	
Altrazine	August	0.10	0.07	0.08	0.05	0.002
	Sept.	0.05	0.07	0.04	0.06	
	July	0.18	0.21	0.20	0.16	
Mancozeb	August	0.19	0.14	0.16	0.11	-------
	Sept.	0.15	0.17	0.13	0.16	
	July	0.06	0.08	0.07	0.06	
Cypermethrin	August	0.08	0.06	0.06	0.04	-------
	Sept.	0.04	0.06	0.03	0.05	
	July	0.07	0.11	0.09	0.07	
Paraquat-dichloride	August	0.10	0.07	0.08	0.04	-------
	Sept.	0.05	0.06	0.05	0.07	
	July	0.28	0.30	0.28	0.21	
Cyfluthrin	August	0.26	0.22	0.24	0.19	-------
	Sept.	0.21	0.26	0.20	0.25	

3.10 Glyphosphate concentration

Glyphosphate concentration ranged from 0.19 mg/L to 0.37 mg/L for the three months, the highest and lowest values were recorded at WF1 and AF in the month of July and August respectively. It is a broad-spectrum systemic herbicide used to kill weeds that compete with crops, therefore the higher concentration recorded in July within the farm might be as a result of a higher application of glyphosphate to control weed during early land preparation prior to

the month of July when heavy downpour of rainfall was observed. The ANOVA showed that there was a statistically significant difference between the locations and months at $p \leq 0.05$ for pesticide concentrations of glyphosphate.

3.11 Atrazine concentration

Atrazine concentration ranged from 0.04 mg/L to 0.13 mg/L for the three months with the highest and lowest values recorded at WF1 and WF2 in the month of July and September respectively. Atrazine is an herbicide of the triazine class used in preventing pre and post emergence broadleaf weeds in crops such as maize, and the higher concentration recorded in July at WF could also be attributed to a higher application of atrazine around the beginning of the rainy season prior to the month of July. Atrazine concentration in all the locations exceeds the WHO (1998) limits for permissible concentration in water and there were statistically significant differences between the locations and months at $p \leq 0.05$.

3.12 Mancozeb concentration

Mancozeb concentration ranged from 0.11 mg/L to 0.21 mg/L for the three months, the highest value was recorded in the month of July at WF1 while the lowest value was recorded in August at AF. This could be as a result of August break, where the rainfall drops since fungi thrives more under heavy rain condition which would engender the use of more Mancozeb related agrochemicals (Madden, 2009). It is a fungicide used to control fungal diseases in crops, variations in its concentration in the water sample can be attributed to variations in its applications at different locations and months. There was no significant difference recorded in its concentration between the locations at $p \leq 0.05$ however, significant difference was recorded between the months.

3.13 Cypermethrin concentration

Cypermethrin concentration ranged from 0.03 mg/L to 0.08 mg/L for the three months, the highest value was recorded in the month of July and August at WF1 and BF respectively while the lowest value was recorded in September at WF2. It is a synthetic pyrethroid used as an insecticide in agriculture, highly toxic to fish and aquatic insects and the variations in its concentration in the water sample can be attributed to variations in its applications at different location and months. There was no significant difference recorded in cypermethrin concentration between the locations at $p \leq 0.05$ while there was significant difference recorded between the months.

3.14 Paraquat dichloride concentration

Paraquat dichloride concentration ranged from 0.04 mg/L to 0.11 mg/L for the three months, the highest value was recorded in the month of July at BF while the lowest value was recorded in August at AF. It is an organic compound classified as a viologen, a salt widely used as an herbicide, it is quick acting and non-selective, killing green plant tissue on contact. Its variation in the water samples can be attributed to variation of its application at different locations in different months, there was no significant difference recorded in paraquat concentration between the locations at $p \leq 0.05$ while there was significant difference recorded between the months.

3.15 Cyfluthrin concentrations

Cyfluthrin concentrations ranged from 0.19 mg/L to 0.3 mg/L for the three months, the highest value was recorded in the month of July at BF while the lowest value was recorded in August at

AF. It is a pyrethroid insecticide used in agriculture to control insects, its variation in the water samples can be attributed to variation of its application at different locations in different months, there was significant difference recorded in paraquat concentration between both the locations and months at $p \leq 0.05$.

4. CONCLUSION

From the physicochemical parameters performed, pH, turbidity, dissolved oxygen, phosphates and atrazine were found to be above the permissible limits for drinking water according to WHO (1998) but within the permissible limits for irrigation water according to FAO (1993), therefore the use of agrochemicals (nitrogenous and phosphatic fertilizers and pesticides) contribute significantly to the deterioration of the water quality of the stream flowing through the farm settlement in Eweje, Odeda Local Government Area. The statistical analysis showed that the rate at which the agrochemical parameters for both fertilizers and pesticides affect the flowing water across the locations, around and within the farm settlement, differ significantly. Likewise, all the parameters for pesticides and fertilizers except phosphate showed significant differences between the months for the flowing stream. It is therefore concluded that the farming activities around Eweje farm settlement is significantly affecting the quality of the stream water flowing through the area, rendering the water unsuitable for drinking purpose except treated, but suitable for irrigation purposes.

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