Effect of Agrochemical use on Water Quality in Parts of Rivers Niger and Kaduna Catchments, North Central, Nigeria.

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Abstract

Effect of agrochemicals on water quality in parts of Rivers Niger and Kaduna Catchments, north central, Nigeria was investigated. Data from the study of agrochemical residue levels in the area remains scanty and therefore needed. Extensive field survey was conducted using various participatory appraisals techniques involving key stakeholders in the area, following which total of sixteen samples of water and sediments for minerals and physico-chemical determinations were collected and transported to the laboratory for analysis. Survey result showed that lower zone ranked the highest with use of agrochemicals (39.4%); upper zone ranked second with 33.5% and middle zone ranked the least with 24.5%. Out of 100% of the respondents, 2.7% disaffirmed the use of pesticides and fertilizers in their farms due to inadequate financial support to farming and inadequate legit borrowing facilities in the study area. Plant minerals NO_3^-, NO_2^-, and PO_4^- concentrations ranging from 0.02 to 5.771ppm were detected in sediments and surface water samples. Most of the findings were above permissible level. Physico-chemical parameters analysed include COD, BOD, Total hardness, Sulphate, Manganese, PH and Chloride. The findings shows considerable number of the parameters were above permissible level. In view, of the aforementioned, we suggest that farmers should be educated and urged to adopt sustainable agrochemical usage. These will guarantee cleaner and healthier environment for all.

Keywords: Agrochemicals, Physico-chemicals, Plant minerals, Sediments, Water quality

1. Introduction

Agrochemicals (fertilisers and pesticides) are intended to facilitate plant growth and protections. Although initially used to improve crop production, however, in achieving this essential mission to care for crops, they have been reported to have negative effects on water quality (Jokha, 2015). Apart from the obvious effects on crops and the food chain, agrochemicals have a wide area of application. Due to these many uses, they move into the surrounding water bodies, therefore having a widespread effect on the physical, chemical and biological processes within aquatic ecosystems (Lakhani, 2015; Bassi *et al.*, 2016; Joko *et al.*, 2017).

Environmental protection has become global focus and important aspect of sustainable development. Proactive measures are being taken by regulatory agencies and relevant stakeholders to address all environmental issues with special attention on chemical pollutants (National Environmental Standards and Regulations Enforcement Agency, 2009).

The amount of agrochemicals usage continue to grow in the study area and most of the users lack awareness of the socioeconomic effects and environmental management plan to prevent or reduce possible environmental issues from their applications. This has become an issue of serious concern in the study area. Managing environmental burden resulting from agrochemical usage continue to frighten the relevant authorities who seem not to be concerned or lack effective capacity to deal with the negative health and environmental situation in this regard.

Environmental management in agriculture sector involving agrochemicals usage is very important to ensure products consumers, nearby communities and the natural environments are protected from the resulting negative effects of their applications. However, if agrochemicals are not used sustainably, it could lead to serious socioeconomic problems thereby endangering existence of life. Nowadays, the environmental issues arising from agrochemicals uses are too numerous which are the direct consequences of improper regulations and enforcement policies particularly in developing countries (NESREA, 2014).

A good number of agriculture chemicals such as endosulfan and dichlorodiphenyltrichloroethane (DDT) have been restricted from use by authorities due to socioeconomic reasons but are still being used in developing countries including Nigeria (Keri and Directorate, 2009; Ojo, 2016). The use of synthetic fertilizers and pesticides in many parts of the world is on the increase (Ramteke and Shirgave, 2012). Rivers Niger and Kaduna sub-catchments are arable land where people practice farming involving intense use of agrochemicals (Ogwueleka, 2014). This practice can eventually cause degradation of water quality and disproportionate effect on the socio-economic wellbeing of the communities in the area.

Further, a research finding by Ogwueleka (2014) suggest that Kaduna Basin and its sub-catchments in part of the study area are highly affected by intense agricultural activities and requires continue monitoring of its resources. Considering the threats from unsustainable agrochemicals usage and weaknesses in conservation of aquatic resources measures, resulting in more adverse effects on socioeconomic wellbeing of communities than expected. Jokha, (2015) and Knauer, (2016) observed that, rapid population growth in addition to change in climate has resulted to a driving force for farmers to use more agrochemicals in agricultural activities near Rivers.

Communities' dependant on the resources from Rivers in the area for livelihood and lack of enough research information about the area that represent risk of agrochemical pollution informed the need for immediate assessment of qualities of its resources to guaranty socioeconomic sustainability. There is presently little research attention on agrochemicals effects on aquatic resources in the area and has resulted to scanty research information about the proposed study area that represent risk of agrochemical pollution. The levels of agriculture chemicals residues in the area under consideration remain under studied to date. Data from the study of agrochemical residue levels in the area is therefore needed. Hence, informed the need for immediate investigation in the area. Finding of this study will provide opportunity for relevant government authorities and all stakeholders in this sector to improve on overall environmental performance.

2. Literature Review

Agrochemicals exposure and poisoning is a highly neglected public health issue in Nigeria and most other developing countries (Ojo, 2016). Citizens and policy makers are not generally aware of this problem due to a lack of valid information on the subject. In view of extensive exposures, adverse health effects and over-stretched health care resources in many developing countries including Nigeria, prevention of pesticide poisoning emerges as the most viable option to reduce the harmful impact on the population (Lewis *et al.*, 2016). This study provides a local scientific basis for the development of strategies to reduce and control poisoning in farming communities by preventing agrochemicals exposures in the environment.

A number of studies on pollution of aquatic environment caused by various chemicals have been carried out on Rivers Niger and Kaduna Basin Catchments in north central Nigeria and reported by various researchers. These include: Assessment of water quality and identification of pollution sources of Kaduna River in Niger State, Nigeria (Ogwueleka, 2014). Ojutiku *et al.,* (2016) worked on Distribution of Phytoplankton and Physico-Chemical Characteristics of Agaie-Lapai Dam, Minna, Niger State, Nigeria. Sidi, *et al.,* (2016) worked on Assessment of Chemical Quality of Water from Shallow Alluvial Aquifers in and around Badeggi, Central Bida Basin, Nigeria. These research were not spatial enough had no specific consideration for agriculture pesticides. Even though little literatures (specifically) on risk of agrochemicals use researches have been found in the study area, a lot of studies related to this topic have been carried out in other parts of Nigeria and these include; Distribution of ecological risk assessment of pesticide residues in surface water, sediment and fish from Ogbesse River, Edo state, Nigeria by Lawrence *et al.,* (2015); Pesticides distribution in surface waters and sediments of lotic and lentic ecosystems in Agbede wetlands by Dirisu *et al.,* (2016;. Assessment of Dichlorvos and Endosulfan pesticide residue levels in selected fruits and vegetables sold in some major markets in Ibadan, Oyo state, Nigeria by Bamigboye *et al.,* (2017); Assessment of pesticide residue levels in vegetables sold in some markets in Lagos state, Nigeria by Njoku *et al.,* (2017;. However these research were also not spatial enough and had no consideration for plant nutrients. Thus, this study attempted to fill this gap.

3. Methodology

Study area

The study area for the investigation is communities in parts of Rivers Niger and Kaduna Sub-catchments, Niger State which lies between Longitude 3˚30'N and 7˚20'E and Latitude 8˚22'N and 11˚30'N; located at the Guinea Savanah vegetation zone in the north central part of Nigeria (Figure 1). Rivers Niger and Kaduna sub-catchments are arable land where people practice agricultural activities close to the Rivers (Ja'agi & Baba, 2015; Ogwueleka, 2014). The study area was divided into zones according to altitude. Along River Niger, the Upper zone is from Rabba village in Mokwa Local Government Area (LGA), Middle zone is at Muregi and the Lower zone is after Muregi in Mokwa LGA down to Baro village in Agaie LGA. Study area along River Kaduna was divided into two zones. Upper zone is from Wuya village in Lavun LGA and the Lower zone from half way down to Muregi. The major economic activities of the communities living around the area are agriculture and fishing. These are the leading sector in terms of employment, income earning and overall contribution to the socio-economic wellbeing of the people.

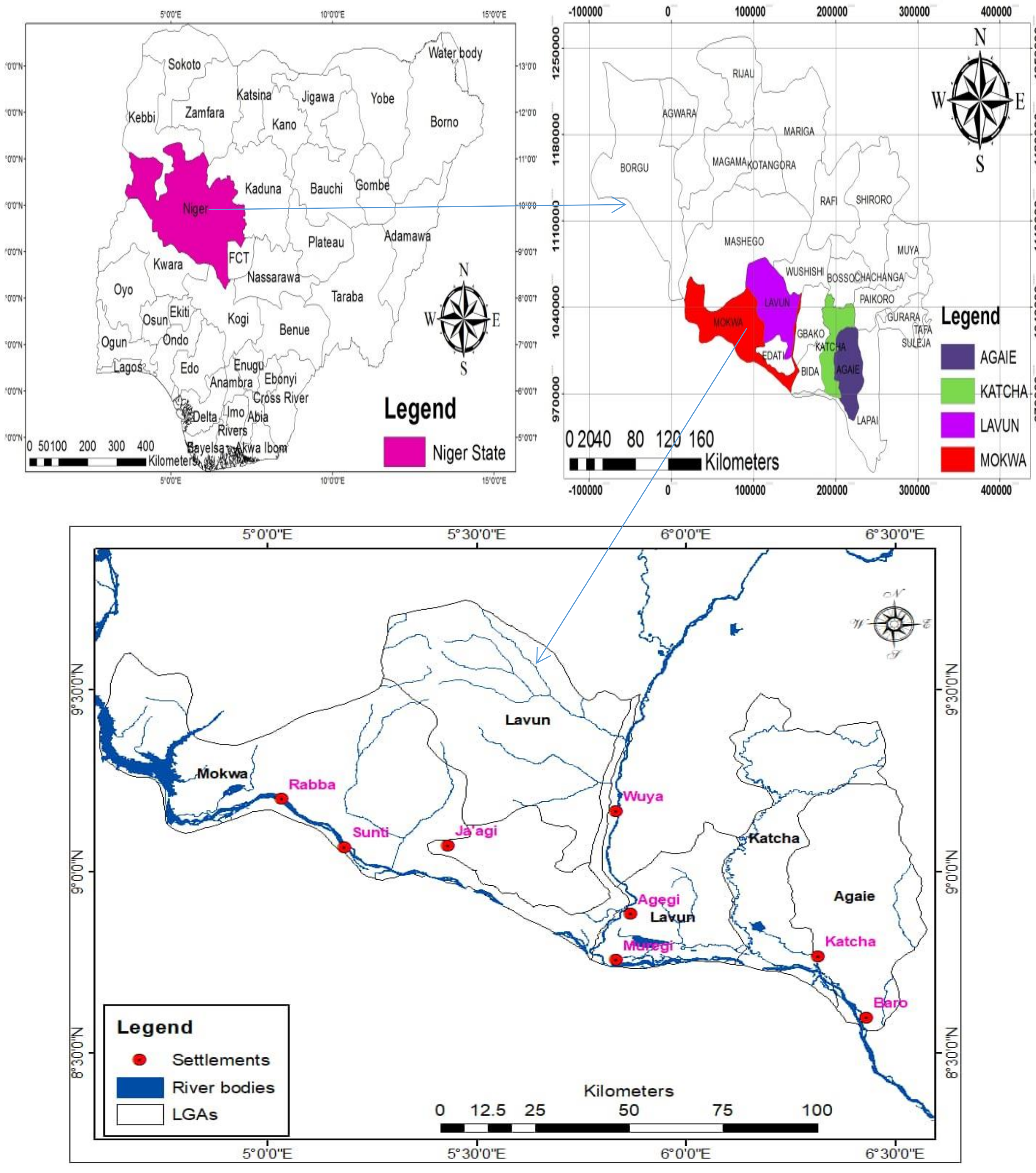

Figure 1: The study Area (Parts of Rivers Niger and Kaduna Basin, Niger State)

Sampling point's identification: Water and Sediment samples were collected from eight selected sampling points in the study area (Table. 1). The eight sampling points was based on altitude and information from key stakeholders in the area. In order to ascertain the proper points for water and sediment samples collection, qualitative information from initial field survey were used. Samples were collected using standard procedures for water and sediment samples collection and preservation. Each sampling point was georeferenced using Global Position System (GPS) device.

Table.1 Description of the surface water and sediment sampling sites

s/n	Site Reference/Zones	Coordinates	Site Characteristics
1	Upper Zone (RN) S1 & W1 S2 & W2 S3 & W3	 9°14’53” N 5°83’37”E 9°11'09" N 5°26'19” E 9°11'43” N 5°18'38” E	Domestic activities, farming, fishing and settlements
2	Middle Zone (RN) S4 & W4	 8°45'25” N 5°50’38” E	Domestic activities, farming, fishing and settlements
3	Lower Zone (RN) S5 & W5 S6 & W6	 8°35'11” N 6°25'59” E 8°46'12” N 6°18'42” E	Domestic activities, farming, fishing and settlements
4	Upper Zone (RK) S7 & W7	 9°09'24” N 5°49'39” E	Domestic activities, farming, fishing and settlements
5	Lower Zone (RK) S8 & W8	 8°50'35” N 5°50'39” E	Domestic activities, farming, fishing and settlements

RN = River Niger, RK = River Kaduna, W = Water sampling site, S = Sediment sampling sites

Water Sampling and Preservation

A total of sixteen samples of water and sediments for minerals and physico-chemical determinations were collected, water samples were analysed insitu for a number of physicochemical parameters, preserved, kept in cool boxes and later transported to the laboratory for analysis. In the Laboratory, water and sediments samples for Minerals and physico-chemical determinations were analysed immediately upon arrival.

Laboratory Analysis: Plant Minerals was analysed spectrophotometrically following the methods outlined by APHA/AWWA/WEF. (2005). Physico-chemical analysis was conducted using HENNA Multiparameter Analyser for insitu analysis and other parameters were determined following method outlined by Federation & American Public Health Association APHA. (2005).

Statistical Analysis

Data obtained from administered questionnaire and interview schedules of farmers and key stakeholders in the area was analysed for agrochemicals use pattern using descriptive statistical methods (frequency, percentage and mean).

4. Results and Discussion

4.1 Agrochemicals Use Attributable to Water Quality Degradation in Farming Activities in the Study Area

Use of Fertilizer and Pesticide in Farming

As indicated in Table 1, there were high use of pesticide and fertilizer in farming activities by the respondents in the study area. Lower zone ranked the highest with use of pesticides and fertilizer (39.4%); upper zone ranked second with 33.5% and middle zone ranked the least with 24.5%. Out of 100% of the respondents, 2.7% disaffirmed the use of pesticides and fertilizers in their farms due to inadequate financial support to farming and inadequate legit borrowing facilities in the study area. The types of fertilizers used in the study area by the respondents include Nitrogen Phosphate Potassium NPK, Nitrogen Phosphate, Prilled Urea, Calcium Ammonium Nitrate and Ammonium Sulphate Nitrate. The pesticides used by the respondents in the study area include Cypermethrin, 2.4 D - Dichlorophenoxy-acetic acid, Gramaxone super and Prime force (Dichlovos). This implied that majority of respondents used fertilizer and pesticide for farming activities in the study area.

Table 1: Use of Fertilizer and Pesticide in Farming

Options	**Upper zone**		**Middle zone**		**Lower zone**	
Yes	117	33.5%	85	24.3%	138	39.6%
No	06	1.8%	01	0.3%	02	0.6%
Total	123	35.2%	86	24.6%	141	40.2%

Source: Field Survey (2019)

Fertilizer Application per Hectare

As indicated in Table 2, fertilizer application per hectare ranges from 50kg to 170kg in the study area. 121 – 170kg fertilizer application ranked the highest in lower zone and 101 – 120kg ranked the least in middle zone. This implies that the respondents in the study area applied high rate of fertilizer during farming activities and it improved crop yield but in turn lead to water quality degradation.

Table 2: Fertilizer Application per Hectare

Options	**Upper zone**		**Middle zone**		**Lower zone**	
50 – 100kg	47	13.4%	21	6.0%	41	11.7%
101 – 120kg	45	12.9%	20	5.7%	31	8.8%
121 – 170kg	31	8.9%	45	12.9%	69	19.7%
Total	123	35.2%	86	24.6%	141	40.2%

Source: Field Survey (2019)

Pesticide Application per Hectare

As indicated in Table 3, pesticide application per hectare ranges from 5 to 10litres in the study area. 10 litres and above of pesticide application ranked the highest in lower zone with 69 respondents and 5 – 7 litres ranked the least in middle zone with 19 respondents. This implies that the respondents in the study area applied high rate of pesticide during farming activities and it improved crop yield but in turn lead to water quality degradation.

Table 3: Pesticide Application per Hectare

Options	**Upper zone**		**Middle zone**		**Lower zone**	
5 – 7litres	41	11.7%	19	5.4%	41	11.7%
8 – 9litres	45	12.9%	20	5.7%	31	8.8%
10 litres and above	37	10.6%	47	13.4%	69	19.7%
Total	123	35.2%	86	24.6%	141	40.2%

Source: Field Survey (2019)

4.2 Extent of Occurrence of Agrochemicals in Surface Water and Sediment Samples, and Water Quality Status in the Study Area

As revealed in Table 4, Manganese values within the study area ranges from 0.08 in W1 to 0.74 in W7. The maximum permitted level is 0.2 and the ones within this range include 0.08 and 0.16 in W1 and W3. The remaining six sample points contains manganese as toxic element which can cause neurological disorder in human. For Nitrite, the maximum permitted level is 0.2 and the sample points within this range were W1, W2, W3 and W4 with values of 0.05, 0.02, 0.16 and 0.18. The sample points above the maximum permitted level include W5 to W8 with values of 0.25, 0.28, 0.34, and 0.56. This can leads to blue baby syndrome in infants under 3 months. The high nitrite level could be attributed to fertilizer application on agricultural activities in the study area.

Table 4: Physicochemical Analysis on Water Samples

Parameter (ppm)	W1	W2	W3	W4	W5	W6	W7	W8
Nitrates	0.256	N.D	0.893	1.764	1.080	1.142	1.274	2.626
Nitrite	0.05	0.02	0.16	0.18	0.25	0.28	0.34	0.56
Ammonium	-	-	-	-	-	-	-	-
Phosphate	N.D	N.D	N.D	0.715	0.229	3.969	4.564	1.294
Sulphate	2.07	0.69	1.02	1.57	1.68	1.88	2.15	
Manganese	0.08	0.25	0.16	0.57	0.62	1.06	0.74	0.65
Chloride	35.5	53.3	71.0	71.0	60.40	63.90	35.6	106.5
COD	30.05	25.65	35.70	32.06	28.30	40.07	24.80	45.06
BOD	12.25	9.82	15.60	13.20	12.00	16.02	10.85	18.15
TSS	45.6	30.0	52.00	49.62	35.02	40.52	38.65	53.05
Total Hardness	7.50	8.60	7.01	6.85	10.52	7.60	8.00	4.60
Potassium	0.56	0.35	1.27	1.54	0.13	2.07	1.68	1.75

Note: W = Water samples, N.D = not detected

Nitrate ranged between 0.256ppm and 2.626ppm at the study area as indicated in Table 4. The acceptable limit for Nitrate is 1-2ppm and water sample W8 (2.626ppm) have exceeded that level which could have serious negative health implications on the inhabitants of the study area. Nitrates are an essential source of nitrogen (N) for plants. When nitrogen fertilizers are used to enrich soils, nitrates may be carried by rain, irrigation and other surface waters through the soil into groundwater which may be the cause of high nitrate level in W8 of the water sample. Human and animal wastes within the study area can also contribute to nitrate contamination of the Rivers. Nitrates can be harmful to humans if they exceed acceptable limits because our intestines cannot break them down into nitrites which affect the ability of red blood cells to carry nitrogen. Nitrates can also cause serious illness in fish and death, these decreases fish population. This agreed with the finding of Eziashi (2015) and Waite (2011).

The relatively high levels of BOD (9.82-18.15 ppm) can be attributed to the presence of decaying organic matter from possible use of herbicides. BOD has been a fair measure of cleanliness of any water on the basis that values less than 1-2 ppm are considered clean, 3 ppm fairly clean, 5 ppm doubtful and 10 ppm definitely deity.

Table 5: Physicochemical Analysis on Sediment Samples

Parameter (ppm)	S1	S2	S3	S4	S5	S6	S7	S8
Nitrates	2.004	2.098	2.095	2.144	2.137	1.896	2.556	3.147
Nitrite	0.07	0.63	0.71	0.69	0.75	0.54	1.02	1.16
Ammonium	-	-	-	-	-	-	-	-
Phosphate	1.546	2.552	1.965	1.269	2.099	4.564	5.771	3.776
Sulphate	15.06	5.28	6.57	10.06	12.58	22.68	8.65	7.96
Manganese	0.20	0.65	0.42	1.49	1.60	2.79	1.95	2.45
Chloride	23.08	37.31	48.28	41.89	35.64	40.90	22.78	72.42
COD	NA	NA	NA	NA	NA	NA	NA	NA
BOD	NA	NA	NA	NA	NA	NA	NA	NA
TSS	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness	NA	NA	NA	NA	NA	NA	NA	NA
Potassium (mg/kg)	35.02	12.56	40.65	55.65	10.56	62.75	45.09	58.25

Note: NA = Not Available, S = Sediment samples

Nitrate ranged between 1.896ppm and 3.147ppm at the study area as indicated in Table 5. The acceptable limit for Nitrate is 1-2ppm and sediment samples S1, S2, S3, S4, S5, S7 and S8 have exceeded that level which in turn will affect the health of the inhabitants of the study area. Maximum permitted level for Potassium ranges between 3.6 – 5.2ppm and all the sediment samples has higher values which in turn can cause kidney and heart diseases in human health. Phosphates and nitrates are important nutrients to plant bloom and the eutrophication of lakes rate of plant growth observed in the river.

5. Conclusion

In conclusion, people in the study area are looking at surface water in the rivers as an infinite resource thereby, ignoring its real value. Rather, more attention is given to the farming sectors which in turn degraded the water quality. The surface water quality of study area is not fit in this present form to serve the domestic purpose of drinking, washing, cooking for the local inhabitants without further treatment. Taking into account the travelling delay of surface water in the rivers, these results indicate that the poor water quality in the surface water of the catchment probably is not only due to recent (excessive) fertilisation as well as pesticides use in surrounding parcels, but can also be attributed to historical pollution in parcels located at a greater distance. In view, of the aforementioned, we suggest that farmers should be educated to change farming practices and adopt sustainable agrochemical usage. In the future, the proliferation of environmental policies, research and the collation of knowledge will hopefully improve the ways in which sustainable farming interacts with surface water resources precisely the rivers in the study area to promote and reach overall environmental quality standards.

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