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Pollution Load by Synthetic Pesticide Residues in Water from Six Selected Points in the Downstream of River Benue, Viniklang, Jimeta Adamawa State

Mustapha Dauda[1], Abdullahi, S. M[2], Ahmad, A.[3]

[1]Department of Biological Sciences, University of Maiduguri, PMB 1069, Maiduguri
[2]Department of Biological Sciences, Federal University Kashere, Gombe
[3]Depatment of Zoology, Modibbo Adama University of Technology, PMB 2076, Yola

Corresponding Author: Mustapha Dauda

ABSTRACT

This work has quantified the pollution load by organochlorine and pyrethroids synthetic pesticide residues in the downstream of River Benue, Adamawa State, Nigeria with specific objectives of investigating the presence of synthetic pesticide residues, determine the respective concentrations of the residues as well as the determination of ecological implications of the residues. Water samples were collected from the River using plastic bottles. A total of six samples of water were collected from six points at an interval of 1 kilometer apart from the Downstream of the River Benue. The samples were taken to the laboratory and extracted using acetone, n-hexane and Dichloromethane. The extracts were analyzed using Gas Chromatography (GCMS, 7890, MSD, 5977A, Agilent Tech). The results revealed a total of 11 pesticides residues from the six samples media belonging to two classes of pesticide on the basis of chemical composition, Organochlorine and Pyrethroids. The concentration of organochlorine residues in water ranges from 0.49±0.07 to 4.61±1.01 (µ/l) and that of Pyrethroids ranges from 0.09±0.02 to 0.85±0.11 respectively. The result therefore showed normal values for organochlorines on comparison with global standard which may be attributed to their banned, however, recorded highest values than pyrethroids in the study samples. Pyrethroids residues on the other hand exceeded the normal value, hence, far beyond negligible limit as they may post adverse effects. This therefore necessitates a continuous monitoring of these residues.

Keywords: Pollution load, synthetic pesticide, Organochlorine, Pyrethroid, River Benue

INTRODUCTION

The role of synthetic pesticides in agriculture in particular is to control target pest by killing, weakening or at least repelling the pest to reduce agricultural lost, however, most of the properties of these pesticides makes them to be poisonous to other non-target organisms including aquatic organisms, birds, animals and humans. Thus, these pesticides are not target specific. The constant exposure to these pesticides by non-target species may induce toxicity once it crosses the threshold limit in the system. It is known that the major portion of the pesticide applied in an area reaches into healthy environmental components such as aquatic ecosystems (ponds, lakes, rivers and oceans), where they gradually get accumulated into other organisms (Azab et al., 2013).

Pesticides can enter water bodies such as rivers and other surface waters through different routes, among which are wind blowing from aerial application, drifts and runoff driven by precipitation or irrigation which is the most important in terms of peak concentrations. The exposure can cause direct effects on all levels of biological organizations, while the toxicant mode of action largely determines which group of organisms (primary producers, microorganisms, invertebrates or fish) is affected. Due to the interconnectedness of freshwater communities, direct effects of these pesticides can entail several indirect effects. Runoff and erosion therefore account for highest routes of pesticides into aquatic medium. The circumstances for pesticide use present a high risk to communities of aquatic species from spray drift for insecticides and runoff from fields for herbicides. Surface waters are frequently contaminated with pesticides such organochlorine and pyrethroids through their use at levels above those known to be normal to fish and other aquatic invertebrates such as the amphibians and reptiles (Bagchi et al., 2009). A study conducted by (Carriger and Rand, 2008), concluded that adverse effects of endosulfan for instance on fish and invertebrates are of concern when the insecticide get into the aquatic ecosystems.

The repercussion of these pollutants besides general risks to aquatic communities includes habitat loss, disturbed food chains, bioaccumulation into food chains, reproduction disorder in animal species such as amphibians, reptiles among other aquatic organisms (IUCN, 2009). If water contains pesticides at concentration which substantially reduce populations of aquatic plants, it is likely to be associated with low numbers of small animals relative to predators' populations and increased numbers of parasites (Beasly, 2010).

Pesticide pollutants like plastics are mostly not easily susceptible to degradation and thus cause serious pollution problems. Contamination of surface water and fish-kill are the major effects of the toxic discharge from agricultural pesticides. The major impact involves gross changes in water quality such as dissolved oxygen reduction and reduction in light penetration that's tends to loss in self-purification capability of a lotic water body such as the River Benue (Agarwal et al., 2010).

Globally, pesticides pollution leads to hazardous impact on aquatic organisms (plants and animals). Many studies show an alarming condition of river pollution implications. A detailed study of pesticide accumulation was identified to be higher in some species such as cat fish as compared to carps for instance and have species specific in their tissues like liver, brain and ovary causing hormonal and metabolic disorders (Singh and Singh, 2008).

MATERIALS & METHODS

3.1 Study Area

This study was conducted in the downstream of River Benue, Jimeta, Adamawa State, Nigeria. Jimeta lies between Latitudes 9°14 north of the equator and Longitude 12º 28 east of the Greenwich meridian with an average elevation of about 192m above sea level. The town is the major and most populous town in Adamawa State. The town falls within the Northern Guinea savannah vegetation zone and characterized by a tropical wet and dry climates. Dry season lasts for a minimum of five months (November-March) while the wet season mostly spans from April-October. The annual rainfall is estimated to be 700mm. The National Population Commission [NPC] estimated the inhabitant population of Jimeta as 101,362 (NPC, 2006). The major economic activity of the inhabitant is agriculture involving wet season farming and irrigation at the Benue River bank. Major crops grown are Vegetables, Rice, Maize and cowpea. Fishing is mostly undertaken by residents along the Benue River bank while the Fulani are mostly cattle nomads and breeders (Fig. 1).

3.2. Sampling sites

A total of six sampling points were identified and marked at and interval of 1km apart. The points were named as points A, B, C, D, E and F. These locations were selected on the basis of proximity or otherwise to agricultural activities undergoing around the River bank. All data collection on commonly used pesticides as well as samples collection for the study was strictly restricted within the six selected sites.

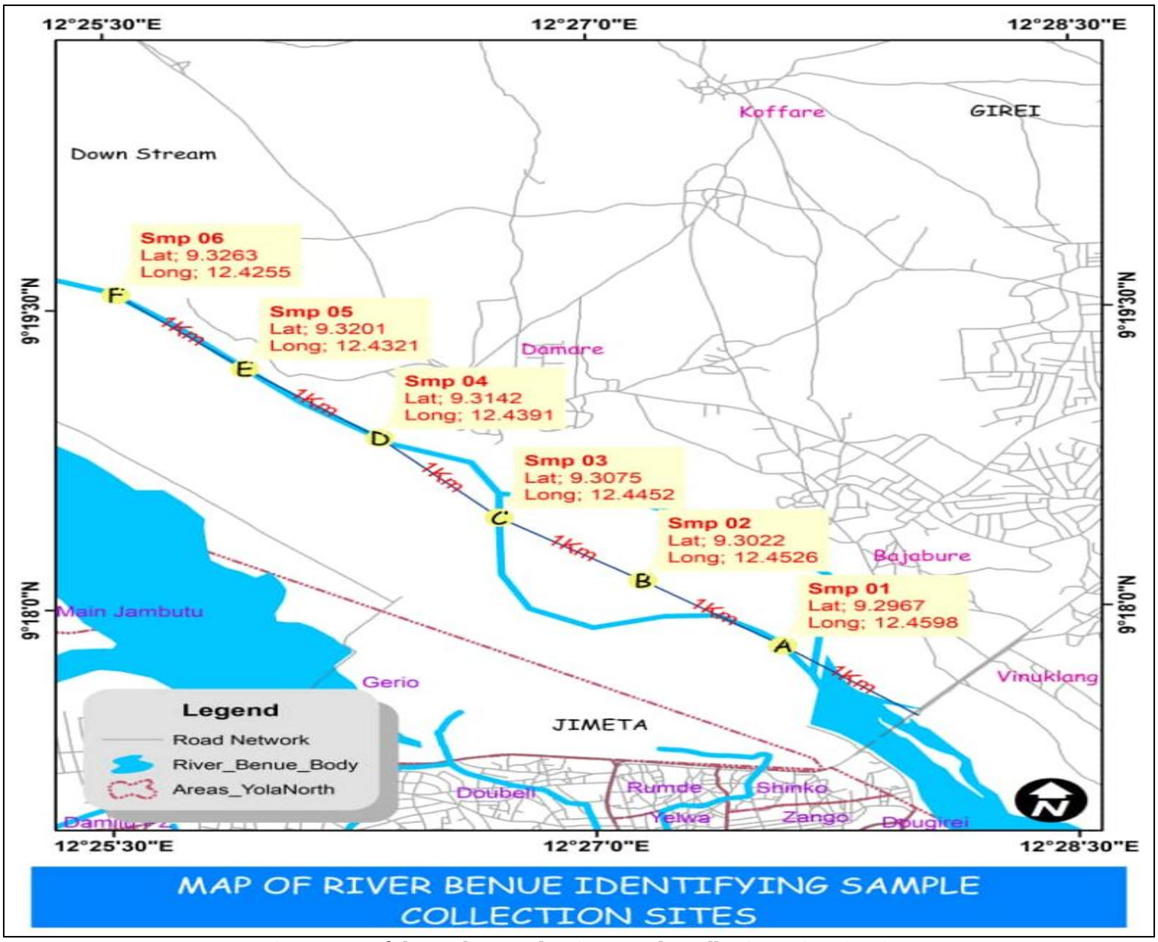

Fig. 1: Map of the study area showing samples collection points (A-F).

3.3. Methods of Data Collection

The data collection procedures were adapted from (Akan et al., 2015).

3.3.1. Samples collection

Water samples were collected at a depth of approximately 1 foot below the water surface and at five to ten meters (05-10m) from the river bank. The samples were collected using 1 litre plastic bottles, filled and transported to Chemistry Department laboratory of Yobe State University, Damaturu where the determination of pesticides residues distribution and their concentrations in water as well as physicochemical analysis was conducted. The sampling bottles were cleaned and rinsed with water using detergent and tap water respectively before collecting the samples.

From all the six points (A-F), water samples were collected at a distance of 1kilometer apart from each other. The samples were then labeled and transported to laboratory for the analysis. For avoidance of pesticides breakdown before the analysis, the samples were stored in a refrigerator at a lowest temperature of 5 to 6ºC.

3.3.2. Pesticide residues extraction from water samples

The water samples were adjusted to p^H 4 with 2 ml Sulphuric acid, while 10g of Sodium chloride was added to all water samples to increase extraction efficiencies. N-hexane (50ml) was also introduced into a two litre separating funnel containing 1 litre of filtered water and was shaken vigorously for 5 minutes and allowed to settle. After complete separation, the organic phase was drained into a 200ml conical flask. The aqueous phase was re-extracted with 50ml of n-hexane. The samples were then centrifuged at 490g for 6 minutes to separate the extract from the pellet. Then, the extracts were combined, evaporated to normal under Nitrogen stream and dissolved again in hexane and then finally analyzed using gas chromatography as presented in the results. The chemicals and reagents used were Acetone, n-hexane, Dichloromethane, Pure Silica gel and Ultrahigh purity water. All concentrations of pesticides in water were expressed in milligrams per liter (mg/l). Pesticides standard analysis were used for this analysis using a GC model of GC 7890B, MSD 5977A.

3.3.3. Gas Chromatography analytical conditions

The career gas of the GC, was 2ml/m throughout the analysis. However, temperatures were 50ºC, -120ºC and -140ºC respectively. The injector temperature of GC machine and the Detector temperature was 300ºC while Detector temperature ranges from 280ºc-290ºC.

Statistical Analysis

Obtained data were analyzed using analysis of variance (ANOVA). A significant level of $p < 0.05$ was adopted for the analysis of variance (ANOVA) using statistical package for social sciences (SPSS) software version 24.

RESULT

Table 1: **Physicochemical Parameters of the Water Samples obtained from the Downstream of River Benue, Jimeta, Adamawa State.**

Sample collection site	(TSS) mg/l	Conductivity s/m	Turbidity mg/l	Salinity mg/l	Temperature ºC	DO mg/l	pH
A	2.5	23.6	4.	1.4	25	1.2	6.
B	3.0	26.1	6.	1.1	23	1.4	7.
C	2.3	23.1	3,	2.0	22	1.0	7
D	1.9	22.9	3.	1.7	25	1.2	7
E	2.7	20.7	4.	2.0	26	1.6	7
F	3.0	21.0	3.	2.1	24	1.7	8

TSS – Total Suspended Solid DO – Dissolved Oxygen Mg/l – Milligram per litre

Table 2: Organochlorine Residues in Water Sample from the Downstream of River Benue, Jimeta, Adamawa State, Nigeria (Concentrations in (mg/l).

Sample collection site	DDE	DDD	DDT	Aldrin	Dieldrin
A	0.69 ± 0.15^a	0.73 ± 0.28^a	0.74 ± 0.11^a	2.44 ± 0.71^b	4.02 ± 0.21^b
B	0.56 ± 0.19^a	0.59 ± 0.11^a	0.58 ± 0.09^a	2.33 ± 0.59^b	3.88 ± 0.39^b
C	0.52 ± 0.22^a	0.49 ± 0.27^a	0.49 ± 0.07^a	2.99 ± 1.01^b	4.61 ± 1.01^b
D	0.67 ± 0.22^a	1.09 ± 0.60^b	0.64 ± 0.14^a	2.41 ± 0.19^b	3.70 ± 1.00^b
E	0.99 ± 0.37^a	0.89 ± 0.17^a	0.97 ± 0.21^a	2.87 ± 0.17^b	3.87 ± 0.41^b
F	1.01 ± 0.29^b	1.14 ± 0.26^b	0.71 ± 0.07^a	3.02 ± 0.27^b	4.08 ± 1.02^b
Total	**4.44±1.44**	**4.93±1.69**	**4.13±0.69**	**16.06±2.94**	**24.16±4.04**

Values are expressed as ± standard error of mean. Different superscript values in the same row indicate significant difference at 0.05 level ($p<0.05$) while values having same superscript on same row shows no significant different.

Table 3: Pyrethroid Pesticide Residues in Water Samples collected from the Downstream of River Benue Jimeta, Adamawa State, Nigeria (Concentrations in mg/l).

Sample collection site	Cypermethrin	Permethrin	Deltamethrin	Befenthrin	Allethrin	Resmethrin
A	0.65 ± 0.01^a	0.60 ± 0.01^a	0.25 ± 0.01^b	0.65 ± 0.02^a	0.25 ± 0.03^b	0.09 ± 0.02^b
B	0.59 ± 0.01^a	0.57 ± 0.04^a	0.27 ± 0.00^b	0.57 ± 0.06^a	0.31 ± 0.01^b	0.11 ± 0.01^b
C	0.71 ± 0.19^a	0.69 ± 0.21^a	0.74 ± 0.03^a	0.41 ± 0.01^b	0.37 ± 0.21^b	0.21 ± 0.10^b
D	0.65 ± 0.11^a	0.63 ± 0.12^a	0.67 ± 0.07^a	0.53 ± 0.11^b	0.44 ± 0.13^b	0.17 ± 0.07^b
E	0.57 ± 0.10^a	0.59 ± 0.12^a	0.59 ± 0.09^a	0.58 ± 0.10^a	0.27 ± 0.31^b	0.19 ± 0.09^b
F	0.80 ± 0.10^a	0.85 ± 0.11^a	0.83 ± 0.11^a	0.81 ± 0.04^a	0.23 ± 0.07^b	0.20 ± 0.03^b
Total	**3.97±0.52**	**3.93±0.61**	**3.35±0.31**	**3.55±0.33**	**1.87±0.76**	**0.97±0.32**

Values are expressed as ± standard error of mean. Different superscript values in the same row indicate significant difference at 0.05 level ($p<0.05$) while values having same superscript on same row shows no significant different.

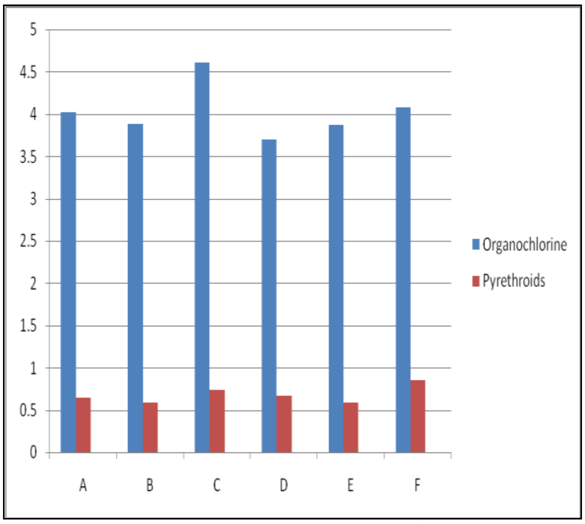

Fig 1: Highest concentrations comparison of Organochlorine and Pyrethroid pesticides residues in water samples from the Downstream of River Benue, Jimeta, Adamawa state Nigeria.

DISCUSSION

5.1. Physicochemical variables of water sample

A total of 7 physicochemical parameters were analyzed from the water samples. The analyzed physicochemical parameters were: Total Suspended Solids, Conductivity, Turbidity, Salinity, $_{P}$H, Dissolved Oxygen and Temperature. All the physicochemical parameters were analyzed using Multi-Parameter Water Quality Meter (MWQM) as described by Sumon et al. (2018a). . None of the physicochemical variables had a significant correlation with pesticide concentrations in water. However, the variations in the physicochemical variables of the water samples might be due to other sources of pollution than pesticides.

Temperature was recorded from all the six samples collected with sample E having the highest temperature while sample C recorded the least. Proximity to river bank or depth might be attributed to the difference in the recorded temperatures. The average temperature from the samples is normal which implies that the temperature is within the range of room temperature.

For salinity, sample F recorded the highest value while sample A had the least value. Samples B, C, D and E all had a neutral value. Sample A value is therefore slightly acidic whereas sample F value is slightly Alkaline. Values for samples B, C, D and E are neutral. This value therefore corresponds to that of Ogah et al. (2015), who conducted a similar study in Makurdi Benue State. However, this finding has contradicts the findings of Chinedu et al.(2017), who also carried out a similar work in the Niger Delta region of Nigeria who obtained higher $_{P}$H values than these one. This variation might be as a result of the Niger Delta being a coastal area.

Turbidity is the measure of water cloudiness. The average turbidity from this result was normal as reported by the (WHO, 2009). Sample B recorded the highest turbidity which might be attributed to the fishing activities around the site making the water to be turbid when compared to the values obtained from samples C, D and F. water becomes turbid when substances like clay, silt and organic matter are present in the water. The values obtained from this research for DO were normal to the survival of fauna and flora of the River Benue, Jimeta, Adamawa State. The highest value was obtained from sample F and while sample C has the least value making the average DO to be normal. For Total Suspended Solids, the least value was recorded in sample D. The average value of TSS obtained from this study showed a little difference with that of Sumon et al. (2018).

5.2. Occurrence and Distribution of Organochlorine and Pyrethroid Pesticides Residues in the studied samples

The result from the analyzed sample of water indicates hundred percent positivity for Organochlorine residues. Five residues of organochlorines comprising of DDD, DDE, DDT, Aldrin and Dieldrin were detected in the water which contradicts to the findings of Ogah et al. (2017) who reported nine residues. Dieldrin had the highest value in water. This followed by Aldrin. DDT had the least value in water which agrees with the study conducted by Akan et al. (2015). Pyrethroid pesticide residues in the samples showed a Hundred percent positivity from this study. Six residues of Pyrethroids were detected from the analyzed water and samples. They were Cypermethrin, Permethrin, Deltamethrin, Befenthrin, Allethrin and Permethrin. Cypermethrin had the highest mean value in water while Resmethrin recorded the least value as presented in table 3. This study also revealed that Pyrethroid pesticides residues had the least mean concentration when compared to Organochlorines residues which strongly corresponds to the findings of Agarwal et al. (2010). The study further revealed that pesticides residues were lower in water samples analyzed than in sediment as reported by Dauda, M. 2020, and this might be attributed to the fact that sediment act as a sink for contaminants thereby having the tendency of accumulating pesticides as reported by Chenedu et al. (2017).

CONCLUSION

This research provided the pollution load by some synthetic pesticide residues in Viniklang, the downstream of River Benue, Jimeta of Adamawa State. The results of the laboratory analysis of this study provides threshold values of pesticide residues of organochlorines and Pyrethroid that were present in water samples collected from the River Benue. Both Organochlorine and Pyrethroid pesticides were 100% positive with varying concentrations in the collected water samples after analysis. A total of 5 Organochlorine and 6 Pyrethroids pesticide residues were detected from the collected samples as in tables 2 and 3 respectively. The concentrations of Organochlorine in water samples for this study were lower when compared to standard levels of WHO/FAO but remain higher on comparison with pyrethroids. This study indicates that Organochlorines residues showed high concentrations than Pyrethroids hence having potential risk to the aquatic balance of the River Benue. The reason of having high concentration of these Organochlorines pesticides residue could be their over dosage or irrational use despite their ban globally. Also, as the threshold values of Pyrethroid residues exceed the recommended dosage in the analyzed samples, there may be potential eco-toxicological effects to non-target aquatic organisms of different trophic levels in food chain.

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