AN INVESTIGATION INTO THE EFFECTS OF AGRICULTURAL EFFLUENT ON THE POLLUTION OF KUNRUN STREAM

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ABSTRACT

An investigation was carried out on the effects of agricultural effluent on the quality of surface water. Two plots of land with an area of 1.5 x 1.5 m^2 square were selected on both sides of the Kunrun stream, Ilorin, Nigeria. Maize (Zea maysl) was planted on the plots. Thereafter 150g of N.P.K. fertilizer was applied, samples of stream water were collected from July to September 2001 (Rainy Season) and Dry Season (October 2001 to march 2002). Physical and chemical analyses of the stream water samples were compared with the World Health Organisation (WHO, 1993) standards for drinking water. The results of water analyzed show that turbidity, colour, potassium and nitrates concentration were higher than the WHO (1993) limits for drinking water for the Rainy Season when runoff was available for washing soil nutrients and thus increased the pollution of downstream water. The values of these parameters during the Dry Season were found to be less those obtained during the Rainy Season and were significantly different at 95% confidence level. The study shows that the degree of pollution by non-point sources due to agricultural activit4esa depend on the activities carried out, type and quantity of fertilizers and herbicides used and the distance of nearby stream.

Keywords: Non-source pollution, agricultural effluent, dry season, rainy season, physical and chemical properties.

INTRODUCTION

There are two basic classifications of surface water contamination. Surface water pollutants can be classified as point sources and non-point or diffuse sources. Point sources occurred as a result of the discharge of several outlets. Examples of point sources include outfall sewers or drainage channels. Non-source pollution or diffuse source is the type of pollution in which pollutants dispersed on the land by human activities are conveyed by rainwater or snowmelt. Non-source water contamination varies with geology, topography of the site, type of vegetative cover, climatic conditions and human activities near the banks of the stream.

US-EPA (1992) reported that agricultural non-point pollution is the primary source of water pollution in the United States of America (USA). States and Federal Agencies in USA have developed voluntary programs to control agricultural non-point pollution, but these programs have not been effective protecting surface water pollution by agricultural non-point pollutants. These programs rely on the use of Best management Practices (BMP) to mitigate non-point source pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available non-point pollution control practices, technologies, practices, sitting criteria, operating methods, or other alternatives.

The principal difficulty in selecting BMP for a particular site is that BMP effectiveness varies from site to site due tot spatial and temporal variations in site conditions such as soils, topography, climate and land management. To improve the effectiveness of BMP, long term continuous simulation models that can simulate long-term spatial and temporal changes in land management that affect runoff and top soil losses. To compound the problem, not all areas of a watershed contribute equally to non-source pollution. Numerous studies have indicated that for many watersheds, a few critical areas are responsible for a disproportionate amount of pollution (Dickinson *et al.* 1990, Dillaha 1990, Maas *et al.* 1985). Consequently, pollution control should be targeted to the critical areas to maximize improvements in downstream water quality. Dickinson *et al.* (1990) reported that targeting non-point source pollution resources has the potential to triple pollutant reduction, substantially reduce funding requirements and minimize the area affected by restrictive land management practices. The objective of this paper is to determine the pollution potentials of agricultural wastes and the effects of the direction of tillage on the concentrations of the effluents.

MATERIALS AND METHOD

Sampling of Effluent

Two plots of land with an area of 1.5 x 1.5m^2 square were selected on both sides of the Kunrun stream located on latitude $08^0 30'$N and longitude $04^0 35'$E in the Southern Guinea Savannah Zone of Nigeria. The distance of plot 1 (located at the right side of the stream) was 1.0m to the stream while the distance of plot 2 (also located at the right side of the stream) was 2.5m to the stream. The distance of plot 3 to the stream was equal that of plot 1 but located in the left side of the stream. The distance of plot 4 to the stream was equal to that between plot 2 and the stream. The plots were bonded by ridges and aligned so that plots 1 and 3 were parallel to the direction of the stream. Maize (*Zea maysl*) was planted on the four plots with a row spacing of 25cm and 150g of N.P.K. 15:15:15 fertilizer was applied.

Analysis of Effluent

Runoff samples were collected from the four plots during 2001 Rainy Season and 2001/2002 Dry Season. Physical and chemical analyses of samples of runoff water from the treated plots during the 2001 Rainy Season were compared with those of stream water collected during the 2001/2002 Dry Season when no runoff occurred. The results of the analyzed water samples were also compared with the World Health Organization (WHO, 1 993) st andards for drinking water. Effluent samples were collected from each runoff plot before they enter the stream. Sampling was done with a 2-Litre container thoroughly washed before use. After collection, the container was washed and sterilized for further usage. Parameters such as turbidity, total solids, pH, water hardness, contents of iron, copper, manganese, magnesium, lead, calcium and electrical conductivity were determined using the procedure described by American Public Health Association (APHA, 1995). Only 160ml of the sampled water was collected in a bottle sterilized with sodium trixosulpahte. Both the bottle and the stopper sterilized and wrapped with aluminium foil to protect it from contamination during handling. The results contained during the Rainy Season were statistically compared with that of the Dry Season of the using the Least Significance Difference (LSD) t est. The results obtained during the Dry Season were used as a control test since no runoff occurred. Water a pplied t o t he t reated plots was spot wetting.

RESULTS AND DISCUSSION

Table 1 shows the result of the soil physical properties. The soil on both sides of the soil was predominantly sandy loam. The bulk density for plots 1 and 2 was 1.6g/cm^3 while that of plots 3 and 4 was 1.5g/cm^3. The field capacity o f 9 .1 and 1 0.5% were recorded on plots 1, 2, 3 and 4 respectively. This was considered because except the field capacity is exceeded no runoff will occur. The results of analyzed water are as shown in Tables 2 to 5.

Table 1: Plots soil Physical Properties

Characteristics	Plots 1 & 2	Plots 3 & r
Soil type	Sandy loam	Sandy loam
Field capacity	9.1%	10.5%
Field slope	0.75%	2.10%
Mass density	1.6g/cm^3	1.5g/cm^3
Porosity	34.5%	37.8%
Bulk density	1.7g/cm^3	1.6g/cm^3

The values recorded for turbidity during the 2001 Rainy Season (Tables 2 – 4) ranging from 17.6 to 34.5 NTU were higher than those of the 2002 Dry Season (Table 5) ranging from 11.5 to 14.5 NTU of the runoff from the plots polluting the stream water. Turbidity values recorded during the Dry Season were found to be significantly d ifferent at 5 % level from t hose obtained d uring t he R ainy S eason. T he values recorded in Tables 2 – 5 were higher than the WHO (1993) recommended limits of 5NTU for drinking water. This shows that effluent from the plots contributed a lot to the pollution of the stream. Other physical parameters in Tables 2 – 5 following the same order with turbidity include colour, suspended, dissolved and total solids.

For nitrates, the highest concentration of (28.4mg/1) was recorded in Table 4 during the peak of the Rainy Season. The reason for this value is because of the high content of nitrogen available in the fertilizer. Low nitrate values were recorded during the Dry Season in Table 5 because no rain occurred to wash away the nitrate salts derived from the fertilizer used. Phosphorus and potassium followed the same other as nitrogen. For potassium, the h ighest concentration of 2.6 mg/l (Table 3) was obtained on plot A, which is plot tilled in the direction of runoff (slope). Lower concentrations of potassium of 0.5 and 0.7 mg/1 were obtained during the Dry Season as shown in Table 5 and were significantly different at 95% confidence level from the ones obtained during the Rainy Season. This shows that potassium ion gained from the fertilizer used increased the concentration of potassium in the stream water.

In Table 6, the higher grain yield of 0.84kg and 0.82kg were obtained on plots tilled in the direction perpendicular to the slope than those of 0.74kg and 0.71kg recorded on plots tilled in the direction of the slope. This shows that the higher amount of runoff occurring on plots tilled in the direction of the slope led to the depletion of nutrients available for crop growth.

Table 2: Characteristics of runoff sampled from the plots (July 2001)

Parameters	Stream samples			
	A	B	C	D
Methyl orange alkalinity (mg/1)	100	80	75	75
Total hardness (mg/l)	52	52	48	40
Magnesium Hardness (mg/l)	20	24	28	20
Calcium Hardness	32	28	20	20
Magnesium Total (mg/l)	10.8	11.6	12.2	10.8
Calcium Total (mg/l)	12.8	11.2	8.0	8.0
Total solids (mg/l)	314	308	408	432
Dissolved solids (mg/l)	98	108	304	316
Suspended solids (mg/l)	216	200	104	116
CO_2 (mg/l)	2.0	2.0	2.5	2.3
Cl^- (mg/l)	8.0	12.0	10.0	10.0
Fe_2^{2+} (mg/i)	0.00	0.00	0.00	0.00
Mn^{2+}(mg/l)	7.6	6.8	7.0	6.8
NO_3^- (mg/l)	26.4	22.6	23.8	22.2
PO_4^{3-} (mg/l)	412	416	400	392
NH_3 (mg/l)	1.5	1.2	0.064	0.082
SO_4^{2-} (mg/l)	55	70	48	43
K^+ (mg/l)	2.1	2.4	1.6	1.3
Na^+ (mg/l)	1.2	0.9	1.2	1.7
Colour (HU)	28.6	32.4	70	80
Turbidity (NTU)	30.76	26.22	17.6	22.5
Electrical conductivity (Ms)	0.056	0.068	0.064	0.058

Where A = represent runoff from plot 1 parallel to stream flow,

B = represent runoff from plot 2 perpendicular to stream flow,

C = represent runoff from plot 3 parallel to stream flow,

D = represent runoff from plot 4 perpendicular to stream flow

Table 3: Characteristics of runoff sampled from the plots (August 2001

Parameters	Stream samples			
	A	B	C	D
Methyl orange alkalinity (mg/1)	115	90	75	70
Total hardness (mg/l)	64	62	52	44
Magnesium Hardness (mg/l)	32	30	28	20
Calcium Hardness	32	32	24	24
Magnesium Total (mg/l)	13.4	12.6	12.2	10.8
Calcium Total (mg/l)	12.8	12.8	9.6	9.6
Total solids (mg/l)	296	324	308	330
Dissolved solids (mg/l)	104	112	108	122
Suspended solids (mg/l)	192	212	200	208
CO_2 (mg/l)	3.5	2.5	2.2	3.0
Cl^- (mg/l)	11.0	13.0	11.0	11.5
Fe_2^{2+} (mg/l)	3.0	2.2	2.5	2.5
Mn^{2+}(mg/l)	8.6	7.0	7.0	7.2
NO_3^- (mg/l)	28.6	24.0	25.4	23.0
PO_4^{3-} (mg/l)	1.8	1.4	1.5	2.0
NH_3 (mg/l)	440	436	416	422
SO_4^{2-} (mg/l)	65	70	75	85
K^+ (mg/l)	2.3	2.6	2.1	1.9
Na^+ (mg/l)	1.5	1.2	1.8	1.5
Colour (HU)	32.6	35.0	39.0	45.0
Turbidity (NTU)	32.2	28.0	33.5	29.6
Electrical conductivity (Ms)	0.060	0.072	0.068	0.076

Where A, B, C and D are as shown in Table 2.

Table 4: Characteristics of runoff sampled during the plots (September 2001)

Parameters	Stream samples			
	A	B	C	D
Methyl orange alkalinity (mg/1)	113	92	75	75
Total hardness (mg/l)	62	62	56	40
Magnesium Hardness (mg/l)	30	30	28	16
Calcium Hardness	32	32	28	24
Magnesium Total (mg/l)	12.8	12.6	12.2	8.4
Calcium Total (mg/l)	12.8	12.8	12.2	8.4
Total solids (mg/l)	312	324	310	330
Dissolved solids (mg/l)	103	116	110	126
Suspended solids (mg/l)	209	208	200	204
CO_2 (mg/l)	3.0	3.5	2.5	3.0
Cl^- (mg/l)	12.0	12.0	12.5	11.0
Fe_2^{2+} (mg/l)	3.2	2.5	2.5	2.7
Mn^{2+}(mg/l)	0.5	0.4	0.3	0.3
NO_3^- (mg/l)	27.8	26.0	24.8	24.0
PO_4^{3-} (mg/l)	1.9	1.6	1.6	2.1
NH_3 (mg/l)	424	440	420	456
SO_4^{2-} (mg/l)	60	86	70	85
K^+ (mg/l)	2.0	2.2	2.3	2.3
Na^+ (mg/l)	1.3	1.0	1.6	1.5
Colour (HU)	31.5	34.5	37.6	43.4
Turbidity (NTU)	30.4	29.2	34.5	27.6
Electrical conductivity (Ms)	0.056	0.068	0.072	0.072

Where A, B, C, and D are shown in Table 2.

Table 5: Characteristics of stream water sampled during the Dry Season 2001/2002

Parameters	Stream Samples		
	November 2001	December 2001	January 2002
Methyl orange alkalinity (mg/1)	65	63	65
Total hardness (mg/l)	64	66	62
Magnesium Hardness (mg/l)	32	34	30
Calcium Hardness	32	32	32
Magnesium Total (mg/l)	13.4	14	12.4
Calcium Total (mg/l)	13.6	13.6	13.6
Total solids (mg/l)	276	284	276
Dissolved solids (mg/l)	210	212	220
Suspended solids (mg/l)	66	72	56
CO_2 (mg/l)	3	2.5	3.5
Cl^- (mg/l)	0.4	0.4	0.6
Fe_2^{2+} (mg/l)	1.5	1.2	1.3
Mn^{2+}(mg/l)	0.2	0.3	0.2
NO_3^- (mg/l)	4.5	4.2	4.0
PO_4^{3-} (mg/l)	0.02	0.02	0.02
NH_3 (mg/l)	150	135	110
SO_4^{2-} (mg/l)	19.5	21.5	20
K^+ (mg/l)	0.5	0.7	0.5
Na^+ (mg/l)	1.2	1.3	1.3
Colour (HU)	25	30	31.5
Turbidity (NTU)	11.5	13.5	14.5
Electrical conductivity (Ms)	114.5	116.5	113.6

Where A, B, C and D are as shown in Table 2.

Table 6: Maize yield

Treatment	Grain Yield (kg)
A	0.84
B	0.74
C	0.82
D	0.71

Where A, B, C and D are as shown in Table 1

CONCLUSIONS

The study shows that there were higher concentrations of the anions and cations of salts like nitrogen, phosphorus, potassium and others during the Rainy Season than those obtained during the Dry Season. Plots aligned parallel to the direction of flow. The study shows that where heavy application of fertilizers and herbicides are applied on agricultural lands, the tendency for adjacent lands to be polluted is high during the Rainy Season. The degree of pollution of surface water by non-point sources like agriculture depend on the activities carried out land, type and quantity of fertilizer and herbicides used, distance of pollution source to the nearby stream and the manner in which pollutants re conveyed to the stream.

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