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Impacts of Agricultural Poultry Farming on Water and Sediment Qualities

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Abstract - Environmental risks and nuisances are associated with poultry farm operations leading to impairment of water and sediment qualities. This study was conducted to assess the effects of poultry farm wastes on water and sediment qualities of Alakata stream in Abeokuta, Nigeria. The Stream was monitored for six months and evaluated for physical and chemical parameters using standard procedures. Ten sampling stations were established; two points before the poultry farm site (controls) upstream while the remaining eight points were selected from the poultry farm downstream at a regular interval. Data collected were subjected to statistical analysis using SPSS 15.0. Results of water quality showed that total solids in control 1, and electrical conductivity in control 2 (samples collected before the poultry discharge point) were significantly lower than the values obtained at the discharge point. Sediment samples were also collected and analyzed for important parameters. Sediment's data exhibited higher mean values organic matter, total kjeldahl nitrogen, sodium and potassium at the poultry discharge point downstream relative to the control samples. The study revealed that water and sediment quality of the study stream had been impaired by the poultry farm operation. The principal component analysis was used to identify the pollution sources of the Stream.

Keywords**:** water quality impairment, poultry waste discharge, multivariate analysis, sampling points

1. Introduction

Discharging of wastes into the water bodies is a phenomenon in most developing nations of the world because streams and rivers are seen as no man's properties. Little is therefore, known about the implications of these wastes on the water and sediment qualities. Poultry wastes in surface water do increase nutrient, solid and metal loads of stream water quality, thereby, leading to algae bloom, reduced light penetration, increased turbidity, bioaccumulation of toxic metals and disruption of ecosystem [1]. Poultry manure is the major pollutant associated with poultry farm operations, which on decomposition reduces oxygen levels of a stream and cause fish death. Other environmental risks and nuisances associated with poultry operations include odor, dust and gases, pesticides, pharmaceutical and pathogens [2]. The excessive emissions of nitrogen, phosphorus, zinc and copper via poultry wastes emanate from excess supplies of protein and phosphorus in poultry formulation and as well by the physiologically inadequate use of essential trace elements [3]; this may adversely affect the both aquatic and terrestrial environments. Ammonia gas is a nasal and respiratory irritant associated with animal manures could also contribute to water quality problems [4]. Nitrates from manure and fertilizers may be leached into groundwater and caused a number of human health problems [5]. Some studies have reported significant levels of Cd, Zn and Pb in poultry manures and poultry manure-amended soil [6, 7]. These metals may found themselves mobilized into the aquatic environment through runoff. The presence of heavy metals in the aquatic ecosystem has far-reaching implications directly to the biota and indirectly to man [8]. Cadmium is one of the most toxic metals with reported carcinogenic effects in humans [9]. The point of attack for cadmium is the kidney and liver where it accumulates in high concentrations, thereby leading to chronic kidney dysfunction. It is toxic to fish and other aquatic organisms [10]. Lead is potentially hazardous and poisonous to most forms of life responsible for quite a number of ailments in humans such as chronic neurological disorders, anemia, brain damage, anorexia, mental deficiency, vomiting and even death in human [11]. Zinc has been found to have low toxicity to man, but prolonged consumption of large doses can result in some health complications such as fatigue, dizziness, and neutropenia [12].

Sediment has been described as a ready sink or reservoir of pollutants, including heavy and trace metals where they concentrate according to the level of pollution [13]. Mann and Lintern [14] observed that sediments played a major role in the transport and storage of contaminants, and are frequently used to identify sources of toxicants, determine dispersion pathways, and locate contaminant sinks in water systems. Sediments have been found to record and time-integrate the contaminant status of an environment [15] and are therefore, also used to measure temporal change and to detect the anthropogenic impacts over time. The main objective of this study is to assess the negative impact of agricultural poultry farm operations on water and sediment qualities of Alakata stream located in Abeokuta.

2. Materials and Methods

2.1. The study area

Alakata stream was located on latitude 7 o 13' N and longitude 3o 26' E along Alabata Road at Isolu village opposite UNAAB second gate in Odeda Local Government of Ogun State Nigeria.

2.2. Sample collection and analysis

A total number of 60 water samples were collected for six months campaign (June-November, 2008) at 10 sampling locations at a regular interval of 100m. Two points were selected before the poultry farm site (serves as controls) upstream while the remaining eight points were selected from the poultry farm downstream. Water samples for physical and chemical properties were collected with clean pre-washed 2 L bottles using hand sampling method. During the sampling, the bottles were first rinsed with the sampled surface water before the actual sampling. The water samples used for metal determination were collected in another 1 L pre-washed bottles and fixed in-situ with 2 mL concentrated acid (HCl). Water analysis was carried out using standard procedures [16]. Parameters determined were pH, temperature, solids (total dissolved solids, total suspended solids, total solids (TS), electrical conductivity, biochemical oxygen demand, anions (Cl-, SO42-), alkalinity, total hardness, total phosphorus, total kjeldahl nitrogen, ammonium-nitrogen and heavy metals (Pb, Cd and Zn). Water pH, temperature, TDS and EC were determined in-situ using appropriate meters. Water soluble ions were analyzed by UV-Spectrometry method while heavy metals by atomic absorption spectrometry (AAS). Na and K were assayed by flame photometer [17]. Water samples for heavy and alkaline metals were digested with concentrated acid prior to determination with AAS and flame photometer, respectively. Briefly, 10 mL HCl was added to 100mL and heated on the hot plate for 30 minutes. Details of the chemical analysis of water samples have been extensively discussed in Ademoroti [18].

Twenty sediment samples were also collected twice (June and November) at the exact points where water samples were collected. Surface sediment samples were collected by scooping with a plastic scoop. Sediment samples were transferred into polythene bags. The samples were air-dried, crushed and pass through a 2 mm mesh sieve [19]. Sediment's parameters investigated include pH, EC, organic matter, TP, TKN, Pb, Cd, Zn, Na and K. pH and EC were determined by measuring about 2 g of the well-grounded sediment samples dissolved in 100 mL distilled deionized water. pH and EC meter were inserted to measure the parameters. Organic matter was determined by Walkley-Black method [20], TKN and TP by spectrometry [21] while heavy and alkaline metals by atomic absorption spectrometry and flame photometric methods, respectively [18]. The sieved, air-dried sediment sample (2 g) was digested with concentrated mixed acids (HNO3, H2SO4 and HClO4). The digest was filtered into 100 ml volumetric flask and made up to the mark with distilled water. The solution was poured into a clean 120 ml plastic bottle and sent to Obafemi Awolowo University Central Laboratory for heavy metals reading with AAS (BUCK SCIENTIFIC, 200). Na and K were read at Department of EMT, University of Agriculture, Laboratory with flame photometer (MODEL PFP 7, JENWAY, UK).

2.3. Data analysis

Data collected were subjected to statistical evaluations: one-way Analysis of Variance (ANOVA) to test for significance among the means; Pearson's correlation to test for linear relationship among factors; Duncan Multiple Range Test (DMRT), to separate significant means and Principal Component Analysis (PCA) for source identification. PCA attempts to explain the statistical variance of chemical species measured at the receptor site in a number of original variances by a minimum number of significant components. The varimax principal component analysis rotation based on Eigen values greater than 1.0 was used in this study.

3. Results

The results of the stream physical and chemical parameters of the stream are presented in Table 1 and 2 respectively. Figure 2 also highlighted the impacts of the poultry farming on the study stream. Parameters such as EC, TS, alkalinity, BOD, chloride and water hardness have shown a progressive increase from the poultry discharge point downstream. A sharp increase in the concentrations of these parameters has been observed at the discharge point (0m) sampling site. However, there is a decline in the amount of these water quality parameters between sites 100m and 300m. The mean pH, TDS and TSS followed similar pattern with a notable increase at the discharge point of the poultry farm (0m). Sulphate showed the lowest mean value at the poultry farm discharge point (0m) while the lowest mean value was observed at sampling location 400m after the poultry farm. The highest TP value of 11.28±16.46 mgL-1 was observed at site 100m after the poultry farm while the lowest TP mean value of 3.44±2.91 mgL-1 was observed at the 700m point after the poultry farm. Generally, the mean TKN values of samples taken before the poultry farm were not significant ($p<0.05$) higher than those taken after the poultry farm. The highest mean lead (Pb) value was observed at the sampling point 100m before the poultry farm (0.47±0.23 mgL-1) while the lowest Pb value observed at the poultry farm discharge point (0.19±0.17 mgL-1). Cadmium concentrations of the Stream water samples were generally low. The highest mean concentrations of zinc of 0.08±0.07 mgL-1 was observed at the discharge point while zinc value of the stream was found below the detection limit at the sampling site 600m after the poultry farm.

Table 3 shows the multivariate statistics of principal component analysis (PCA) conducted on Alakata stream water quality data purposefully for identification of pollution sources. The PCA extraction was based on Eigen values > 1 revealed six components with almost 99% of the total data variance explained. The first component has high loadings for pH, TDS, EC, Cl, total hardness, alkalinity, Na and K. This factor is designated dissolved substances source probably from the poultry farm and runoff materials. The second component is significantly associated with TSS, TS, phosphate and nitrate-nitrogen suggesting an organic source. A negative correlation was found for TKN in this factor. In the third component are strong significance of DO and BOD which also suggest an organic source. The fourth factor revealed high loadings for Pb, Cd and Zn. TKN and ammonium-nitrate showed a high significance in this component. The factor may indicate heavy metal pollution. The fifth factor also suggests an organic source with loadings for sulphate and total phosphorus. The last component has only temperature as significant parameter and has been tagged an unknown source.

The sediment data of the stream are presented in Figure 2 and Table 4. The mean values of EC, organic matter, TKN, Na and K were generally high between the discharge point and the sampling points after the poultry farm (downstream). Potassium concentration of the stream sediment has the lowest value of 5.0±1.4 mgkg-1 established at distance 200m before the poultry farm discharge point. The highest Zn value of 18.0±1.4 mgkg-1 was observed at the sampling point (400m) after the discharge site downstream. The sediment mean Pb value was high at the discharged point and at point 400m after the poultry farm discharge point. The sediment Cd concentrations were low at most of sampling points. The highest Cd concentration of 0.02±0.03 mgkg-1 was observed at distance 100m after the poultry farm downstream (Table 4). The sediment Zn value revealed the highest mean value of 0.03±0.05 mgkg-1 at the sampling point 600m downstream after the discharge point.

The Pearson's correlation coefficients between water and sediment parameters showed a fairly significant correlation between water-EC and sediment-Na ($r2= 0.464$; $p<0.05$) water-EC and sediment-K ($r2= 0.488$; $p<0.05$). Significant positive association were found between water-Na and sediment-K ($r2= 0.585$; $p<0.01$), and water-K and sediment-K ($r2= 0.515$; $p<0.05$) while a non-significant positive correlation was established for water-TKN and sediment-TKN ($r2= 0.412$).

Table 1: Mean and standard deviation of physical parameters of the stream at different sampling sites farm.

PARAMETERS	200m	100m	0m	100m	200m	300m	400m	500m	600m	700m
Temperature (^oC)	27.27 ± 2.2 [a]	26.92 ± 1.03 [a]	26.08 ± 0.85 [a]	26.98 ± 1.70 [a]	26.92 ± 0.61 [a]	26.18 ± 0.78 [a]	26.38 ± 0.99 [a]	26.38 ± 0.80 [a]	26.43 ± 0.67 [a]	26.35 ± 0.58 [a]
TDS (mgL^{-1})	21.67 ± 16.02 [a]	31.7 ± 33.71 [a]	55.0 ± 10.48 [a]	35.0 ± 16.43 [a]	33.33 ± 15.05 [a]	45.0 ± 28.81 [a]	60.0 ± 31.66[a]	65.0 ± 36.74 [a]	70.0 ± 32.25 [a]	70.0 ± 42.43 [a]
TSS (mgL^{-1})	176.9 ± 16.01 [a]	115.2 ± 33.7 [a]	208.5 ± 10.4 [a]	149.5 ± 16.4 [a]	191.0 ± 15.05 [a]	107.8 ± 28.81 [a]	90.0 ± 31.66 [a]	115.5 ± 36.74 [a]	130.3± 32.24 [a]	105.5 ± 42.42 [a]
Width (m)	1.96 ± 1.89 [ab]	1.29 ± 1.89 [a]	2.72 ± 2.063[ab]	2.56 ± 2.99 [ab]	1.71 ± 0.51 [ab]	1.63 ± 0.78 [ab]	2.51 ± 2.67 [ab]	2.26 ± 1.58 [ab]	4.91 ± 5.58 [b]	-
Depth (m)	0.17 ± 0.06 [bc]	0.21 ± 0.16 [bc]	0.64 ± 0.33 [c]	0.16 ± 0.10 [bc]	0.25 ± 1.03 [bc]	0.21 ± 0.10 [bc]	0.14 ± 0.08 [a]	0.20 ± 0.15 [bc]	0.16 ± 0.10 [bc]	-
Flowrate (m^3s^{-1})	0.00	0.00	0.00	0.02 ± 0.02 [a]	0.00	0.00	0.00	0.03 ± 0.03 [a]	0.05 ± 0.06 [a]	0.00

Means in the same row followed by the same alphabets are not significant at $p<0.05$ according to Duncan multiple range test (DMRT), SD-standard deviation.

Table 2: Mean and standard deviation of chemical parameters of the stream at different sampling sites.

Parameters	200m	100m	0m	100m	200m	300m	400m	500m	600m	700m
pH	6.60 ± 0.54 [a]	6.79 ± 0.36 [ab]	6.92 ± 0.37 [ab]	7.01 ± 0.61 [ab]	6.92 0.34 [ab]	7.19 ± 0.48 [ab]	7.27 ± 0.44 [b]	7.29 ± 0.473[b]	7.35 ± 0.50 [b]	7.25 ± 0.47 [b]
Sulphate (mgL^{-1})	142.4 ± 124.6 [a]	104.5 ± 71.96 [a]	94.11 ± 48.08 [a]	113.2 ± 72.51 [a]	111.23 ± 79.04 [a]	125.0 ± 104.0 [a]	143.1 ± 106.0 [a]	143.4 ± 107.8 [a]	138.7 ± 98.48 [a]	129.3 ± 78.77 [a]
TP (mgL^{-1})	4.68 ± 4.15 [a]	10.2 ± 16.00 [a]	8.78 ± 10.45 [a]	11.28± 16.46 [a]	5.98 ± 6.48 [a]	5.37 ± 3.78 [a]	6.67 ± 6.69 [a]	4.43 ± 4.56 [a]	5.15 ± 3.99 [a]	3.44 ± 2.91 [a]
TK N (mgL^{-1})	3.95 ± 4.71 [a]	2.71 ± 2.59 [a]	3.14 ± 3.43 [a]	2.89 ± 3.06 [a]	3.79 ± 4.47 [a]	3.57 ± 4.27 [a]	2.81 ± 2.93 [a]	2.79 ± 2.63 [a]	3.94 ± 4.29 [a]	2.34 ± 2.31 [a]
Ammonia-nitrogen (mgL^{-1})	0.29 ± 0.30 [a]	0.19 ± 0.19 [a]	0.18 ± 0.17 [a]	0.40 ± 0.346 [a]	0.18 ± 0.19 [a]	0.14 ± 0.11 [a]	0.24 ± 0.20 [a]	0.37 ± 0.42 [a]	0.12 ± 0.11 [a]	0.20 ± 0.24 [a]
Lead (mgL^{-1})	0.30 ± 0.33 [a]	0.47 ± 0.23 [a]	0.19 ± 0.17 [a]	0.20 ± 0.24 [a]	0.22 ± 0.20 [a]	0.25 ± 0.39 [a]	0.36 ± 0.35 [a]	0.38 ± 0.40 [a]	0.21 ± 0.27 [a]	0.27 ± 0.25 [a]
Cadmium (mgL^{-1})	0.03 ± 0.03 [a]	0.02 ± 0.00 [a]	0.07 ± 0.05 [a]	BDL	0.02 ± 0.02 [a]	0.05 ± 0.02 [a]	BDL	0.05± 0.02 [a]	0.02± 0.01 [a]	0.05± 0.01 [a]
Zinc (mgL^{-1})	0.03 ± 0.02 [a]	0.02 ± 0.01 [a]	0.08 ± 0.07 [a]	0.03 ± 0.00 [a]	0.05 ± 0.04 [a]	0.05 ± 0.06 [a]	0.03 ± 0.00 [a]	0.06 ± 0.03 [a]	BDL	0.03 ± 0.02 [a]

Means in the same row followed by the same superscripts are not significant at $p<0.05$ according to Duncan Multiple Range Test (DMRT), SD-standard deviation, BDL –below detection limit (<0.01 for Cd and Zn).

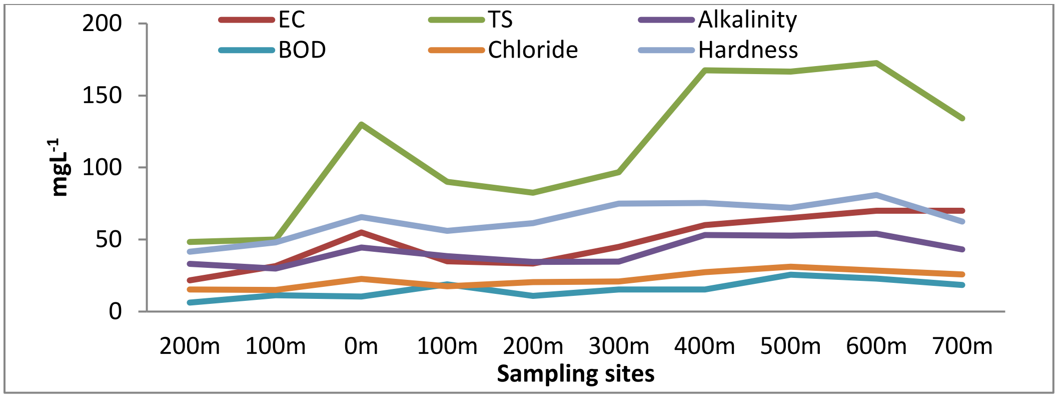

Fig. 1: The trends of surface water parameters from sampling sites.

Table 3: Multivariate analysis of surface water quality data.

	Component						
	1	2	3	4	5	6	Communalities
pH	.867	.224	-.085	.073	-.206	.348	.979
Temperature	-.077	.223	-.014	.139	-.197	.930	.979
TDS	.957	-.112	.038	.200	-.074	-.143	.996
TSS	-.391	.898	-.100	.038	-.016	.170	1.000
TS	-.114	.971	-.100	.111	-.044	.142	1.000
EC	.956	-.177	.026	.188	-.072	-.076	.993
DO	-.259	-.486	.787	.066	-.150	-.052	.952
BOD	.108	-.363	.908	.085	.079	-.128	.997
Cl	.896	-.295	.172	.229	-.030	-.161	1.000
SO4	-.464	.260	-.507	.428	.511	.038	.986
TP	.029	-.092	.005	.149	.965	-.094	.972
TKN	-.051	-.722	.174	.490	.368	.126	.944
NH4-N	.521	-.205	-.016	.809	-.143	.034	.990
NO3-N	-.459	.668	-.076	-.137	.511	.231	.996
TH	.904	-.244	.122	-.143	.233	-.170	.995
Alkalinity	.937	.005	-.119	.228	-.104	.159	.981
Na	.942	-.285	.049	-.007	-.085	.076	.984
K	.742	.183	.439	.163	-.262	-.356	.998
Pb	.289	.012	-.259	.905	-.135	.059	.993
Cd	.006	.373	.509	.685	.267	.246	.999
Zn	.131	-.075	.008	.519	-.816	.145	.979
% Variance	33.7	17.1	14.4	13.3	12.7	7.4	(98.6%)

TDS-total dissolved solids, TSS- total suspended solids, TS- total solids, EC-electrical conductivity, DO-dissolved oxygen, BOD-biochemical oxygen demand, TH-total hardness

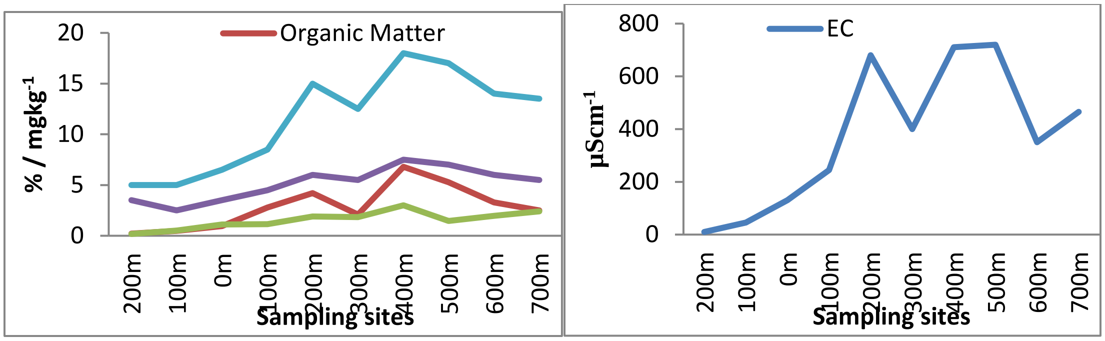

Fig. 2: Mean concentrations of organic matter, TKN, Na, K and EC of sediment.

Table 4: Mean values of the sediment parameters at different sampling sites.

	200m	100m	0m	100m	200m	300m	400m	500m	600m	700m
pH	8.05 ± 0.21 ^{a}	8.10 ± 0.28 ^{a}	8.15 ± 0.64 ^{a}	7.85 ± 0.92 ^{a}	6.70 ± 0.42 ^{a}	7.8 ± 1.7 0^{a}	6.45 ± 0.49 ^{a}	6.80 ± 0.14 ^{a}	7.25 ± 0.78 ^{a}	6.45 ± 0.21 ^{a}
Temp (ºC)	27.45 ± 0.07 ^{a}	27.45 ± 0.07 ^{a}	27.4 ± 0.00 ^{a}	27.35± 0.07 ^{a}	27.45 ± 0.07 ^{a}	27.4 ± 0.00 ^{a}	27.45 ± 0.07 ^{a}	27.4 ± 0.00 ^{a}	27.4 ± 0.00 ^{a}	27.4 ± 0.00 ^{a}
P (mgkg^{-1})	3.57 ± 1.42 ^{a}	1.39 ± 0.24 ^{a}	0.42 ± 0.46 ^{a}	0.72 ±0.98 ^{a}	4.93 ± 2.84 ^{a}	1.33 ± 1.34 ^{a}	0.46 ± 0.24 ^{a}	0.17 ± 0.19 ^{a}	0.75 ± 1.02 ^{a}	3.97 ± 5.57 ^{a}
Pb (mgkg^{-1})	0.72 ± 0.28 ^{a}	0.60 ± 0.23 ^{a}	0.93± 0.920^{a}	0.55 ± 0.16 ^{a}	0.17 ± 0.25 ^{a}	0.43± 0.18 ^{a}	1.03 ± 0.35	0.58 ± 0.67^{a}	0.46 ± 0.04^{a}	0.01± 0.02 ^{a}
Cd (mgkg^{-1})	BDL	0.01 ± 0.01 ^{a}	BDL	0.02 ± 0.03 ^{a}	0.01 ± 0.01^{a}	BDL	BDL	0.01 ± 0.02 ^{a}	0.01 ± 0.01 ^{a}	BDL
Zn (mgkg^{-1})	BDL	0.03 ± 0.04 ^{a}	BDL	BDL	BDL	BDL	0.02 ± 0.03 ^{a}	BDL	0.03 ± 0.05 ^{a}	BDL

Discharge point, Before the discharge point, Means in the same row followed by the same superscripts are not significant at $p<0.05$ according to Duncan Multiple Range Test (DMRT), SD-standard deviation, BDL –below detection limit (<0.005 for Cd and <0.01 for Zn), Temp-Temperature.

4. Discussion

High value of TDS observed at the discharged point (0m) might be linked directly to wastes discharge from the poultry farm while the elevated values between points 300m and 700m after the poultry farm might be related to the impacts of 'Fadama' (wetland) farming practiced on the streambed during the dry season. Roberts [22] recommended value for TSS in fresh water habitat is 25-80 mgL-1. However, the values of TSS of the study stream were greater than this standard. Many negative impacts are associated with high TSS value in surface water. TSS could reduce light penetration in the stream thereby affecting photosynthetic activities of phytoplankton[23].

The higher mean pH value observed in the water samples taken at the discharged point and beyond (downstream) might be linked to discharge of alkaline substances from the poultry operations into the stream. Water pH affects many chemicals and biological processes in water, especially solubility and bioavailability of other substances [24]. Electrical conductivity (EC) is an indication of salinity or total salt content [25]. The sharp rise in EC at discharge point (0m) might be linked to the poultry farm activities. According to Mento [26], the permissible standard for EC in natural water is 400-1250 μS/cm. In drinking water, WHO standard of EC is 250 μS/cm. The mean EC values of the study stream were within these permissible limits.

There was an increase in the mean concentration of chloride at the discharge point of poultry waste to the last sampling point probably as a result of poultry litters discharged directly into the Stream. Concentrations of total phosphate

(TP) of the stream at all the sampling points were extremely high when compared to the standard of 0.03 mgL-1 reported by the Ministry of Environment and Energy [27] in natural water. Swift et al. [28] have identified animal operations as the main source of phosphorus loadings in surface water. High TP values can lead to reduction in stream dissolved oxygen (DO) [29]. To avoid algae bloom in water bodies, the Ministry of the Environment and Energy [27] recommended a limit concentration of phosphorus as 0.03 mgL-1. In uncontaminated stream in USA, phosphate value range between 0.001 and 0.003 mgL-1 [30].

The TKN values of this Stream may be considered high with a large input [31] from animal manure. The mean value of ammonium-nitrogen at the sampling point 100m after the poultry farm was higher than the WHO standard of 0.50 mgL-1 in drinking water [23]. The high value of NH4-N at this point might be linked directly to the poultry wastes discharge. Most of the values of NH4-N obtained in this Stream were greater than Roberts [22] recommended value for ammonia in fresh water habitat given as 0.02 mgL-1 . Ammonia is toxic to aquatic organisms. The mean lead level of the stream was generally high and exceeded the WHO permissible standard of 0.01 mgL-1 [23]. Adekunle et al. [31] observed a lead level of 0.6 mgL-1 in well water sited close to dumping sites. High Pb mean value found at the 100m sampling point before the poultry farm might be attributed to runoff of lead-containing materials from the nearby refuse site, and probably from vehicular emissions [31]. Lead is a pediatric poisonous metal, and also affects central and peripheral nervous system and causes kidney damage [32]. High cadmium level of the stream at the discharge point of the poultry farm into the stream is of health concern being higher than 0.005 mgL-1 Cd permissible standard in drinking water [33]. In China, Xiong et al. [34] has established strong correlations between Cd in the poultry feeds and manures. High concentration of cadmium in water could lead to cancer and impair hormones and enzymes leading to malformations like renal damage [35].

The highest mean concentration of Zn observed at the discharge point of the poultry wastes into the stream may be directly linked to the poultry farm operation, although the values were still within the WHO standard of 5.0 mgL-1 for drinking water [23]. Generally, in natural water, concentration of Zn is usually less than 10 µgL-1 [23]. For protection of aquatic lives against acute and lethal toxic effects, it is recommended that the Zn value should be less than 55 µg L-1, while for chronic effects, the Zn value should not be more than 10 µgL-1 (http://www.env. gov.bc.ca/wat/wq/BCguidelines/ zinc/zinc.html). The average site concentrations of Zn obtained in this study are greater than the values that could cause acute and chronic effects indicating Zn pollution of the study stream. At elevated concentration of 440 mgday-1, Zn has reportedly caused gastric erosion in human [36]. Acute effects of Zn according to WHO [23] also include pulmonary distress, chills, fever and gastroenteritis.

The multivariate analysis of PCA has revealed six major sources of pollution into the study Stream of which organic wastes remained the major contributors (Table 3). Other factors revealed probable emission sources from dissolved substances and heavy metals pollution. In the heavy metal pollution component, it should be noted that high loadings of TKN and NH4-N were found in this factor. This also suggests contribution from the poultry farm operations. The Pearson's correlation analysis has also revealed the inter-relationships among the observed parameters in water and sediment samples. The positive relationship established for water and sediment parameters: water-EC and sediment-Na/K; water and sediment-TKN; water-K and sediment-Na/K suggest common emission sources which might be attributable to poultry farm operations.

The pH value of the sediment analyzed from this study decreased slightly from the point of discharge of poultry wastes to the sampling sites downstream (Table 4). The elevated values of sediment-electrical conductivity at the sites beyond the poultry discharge point might indicate dissolved salts from the poultry operations. This is evident with the significant strong positive correlation observed between EC and organic matter ($r2 = 0.654$; $p<0.05$); EC and TKN ($r2 = 0.582$; $p<0.05$); EC and Na ($r2 = 0.691$; $p<0.01$); EC and K ($r2 = 0.688$; $p<0.01$). At the sampling points taken before the poultry farm, organic matter was low, but at the site of discharge point, it increased slightly. The value of organic matter observed after the poultry farm was high compared to the control samples, which were taken before the poultry farm. According to FPDD [37], the mean results of organic matter of sediment samples at sampling locations 400m, 500m and 600m after the poultry farm were high while those at sampling locations 100m, 300m and 700m taken after the poultry farm were medium. It means that the poultry operation around the Stream has increased the loads of organic substances in the Stream.

The total kjeldahl nitrogen and phosphorus concentrations of the sediment were high at the downstream sites after the discharged point. The high phosphorus value at point 200m before the poultry farm might be related to runoff of dissolved materials into the Stream [38]. The decrease in pH (acidic medium) may result into dissolution of metals from the stream sediment to the water system. This might have resulted into increase in the concentration of metals (Zn, Cd, Na and K) except Pb from the point of discharge of poultry wastes to the last sampling point downstream. The high Pb concentration at the discharge point (0m) might be connected to the poultry farm operations. However, at the point of distance 400m after the poultry farm where the highest concentration of Pb was analyzed might be directly linked to runoff of inorganic fertilizer from a nearby farm [7]. Severe Effects Limit (SEL) based on Ontario Ministry of Environment guidelines for sediment for Cd, Pb and Zn were given as 10, 250 and 820 mgkg-1 respectively [39]. The concentrations of all the heavy metals (Zn, Pb, and Cd) analyzed in the sediment samples were within the SEL values. For K and Na, the values were generally low and increased from the discharge site to the last site downstream.

5. Conclusion

The results obtained from the analysis of physical and chemical parameters of the study Stream revealed that the poultry farm operations around the stream have resulted into elevated level of important water parameters such as total solids, chloride, hardness and cadmium at the point of entry of poultry wastes into the stream (0m). Sediment quality of the Stream was also impaired. The poultry operations have therefore deteriorated the water and sediment qualities of Alakata stream. This may pose detrimental effects on aquatic organisms and human health. Based on the results obtained from water and sediment analyses of Alakata stream, the following recommendations are made: poultry wastes should not be disposed-off via waterways. Animal farms should be sited far away from surface water.

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