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Full Length Research Paper

Interference of organic waste pollution from municipality cattle market/slaughter on adjacent stream/ground water quality

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Chemical contaminants from animal droppings and other organic wastes, nonpoint source (NPS) runoff and abattoir waste water at the municipality cattle market/slaughter lot, Uyo, Nigeria, which increased detritus litter or are leached to ground water, were investigated on the facility borehole and adjacent stream water. Statistical analysis of samples' physico-chemical composition using SPSS ver 17 package, paired-sample statistics and correlation with WHO standards for drinking water, Food and Agriculture Organization (United Nations) (FAO) irrigation water quality and soil extract from the polluted soil of bush fallow and cattle market ground were performed. Paired-samples t-statistics showed no significant difference ($p < 0.01$) between borehole and stream water, but registered varying compatibility (-50 to 100%) with WHO maximum limits for some water properties. Both sources of water were significantly free from the polluting influence of the organic waste runoff and abattoir waste water. Also, no significant correlation ($p < 0.10$) existed between the properties of stream water and abattoir waste water, borehole water and soil extract from the polluted market ground, suggesting that the two water sources may have been buffered from the pollution effect of the organic waste by the adjacent natural bush fallow; therefore, its upgrading is recommended for effective riparian buffering activities.

Key words: Cattle market/slaughter, abattoir waste water, NPS runoff, pollution, surface /ground water quality, World Health Organisation (WHO) compatibility.

INTRODUCTION

Nonpoint source (NPS) pollution is one way of polluting a water body from diffuse sources, such as polluted overland flow from agricultural areas, parks and parking lots, markets, roads and urban unsewered, untreated and unregulated storm runoff, draining into surface water and/or recharging the ground water located on its precinct (United States Department of Agriculture. (USDA), 1997). An animal (cattle/goat) market/slaughter lot was carved out in a suburban area of Uyo municipality for cattle and goat trade in an urban renewal and expansion program. Two sources of water, serving the conjunctive uses of the cattle market, slaughter and traders, existed at the micro-watershed of the facility.

In the scaled-up facility, much organic waste was produced daily on its ground. These included solid wastes and mixed dust from offloading of cattle and goats from their transport trucks and lorries, straws (stale and soiled), waste animal parts and meats, waste water from abattoir, garbage from animal fodder and human food wastes, as well as cattle dung and goat pellet droppings. They were strewn about the market ground while rainfall and the generated – overland flow continued to wash off the pollutants from the wastes, which were at various stages of biodegradation, down the slope to the hedge bush fallow and into the drainage stream. Untreated waste water, washed off the slaughter house, trickled through the bush fallow to the stream while some accumulated in the bush fallow floor; the decomposition of its organic waste materials (offals, intestinal parts, spent blood, carcass and bones) produced large amount of malodorous gases.

The waste water had no concurrent treatment but drained through the ground; this gave such waste water opportunity to drain directly to the adjacent stream and to leach to ground water. For instance, it was observed that organic matter content was very high in the topsoil of the market soil and at its down slope fringe with the adjoining bush fallow; but its dissolved component leached to subsoil depths at the rate of 2 mg/kg organic carbon for 3.5 mg/kg organic matter content (Douglass, 2010; SMI Analytical, 2011). Animal droppings and other organic wastes from the site could leach through the soil to pollute ground water with nitrates and bacteria. The release of pollutants from active or closed animal market/park was a major source of contamination to ground water, surface water and upper soil layer (Zing et al., 2001). The area close to abattoir was reported to have had high chemical toxicity (Bruner et al., 1998) as well as very high concentrations of pollutants in the ground water in Seri Malaysia (Mukhtar et al., 2000). Also, surface water around Siaulli abattoir was reported to be contaminated with pollutants which also tended to increase its chlorides, nitrogen compounds and heavy metal concentrations as well as its effects on human health due to discharge of waste from animal market/park ((Bruner et al, 1998; Tricys, 2002). Therefore, the case of Uyo municipality cattle market/slaughter with common features but different geomorphology needs to be investigated.

The design of the market/slaughter also determines whether or not the organic waste will leach through the soil to pollute ground water. In the present cattle market/slaughter, the borehole is at down slope area of the market where NPS runoff settles out on the sandy loam soil at the bush fallow bordering the market and may advance to pollute the open water body. Therefore, the level of toxicity in the water sources at the precincts of the market/slaughter will be determined by field investigation.

Thus the objectives of the study were: 1) to investigate and compare the chemical and bacteriological properties of the two water sources–ground water and stream water – draining the cattle market/slaughter micro-watershed, 2) to evaluate toxicity and determine any interference of the organic waste pollution on them and 3) to generate suitable eco-friendly management recommendation for the safe and sustained economic operation of the cattle market/slaughter.

MATERIALS AND METHODS

Main water sources at the suburban animal market/park were the borehole which served the residence, and the adjoining stream, which served the residents and the villagers and animals.

Sample collection

One-litre transparent plastic bottles were labeled accordingly for borehole (BH) and surface stream (SW) and used to collect water samples for chemical analysis. Sample bottles were thoroughly washed and rinsed with ethanol and sample water. For runoff water, the sample bottles were placed horizontally against the direction of stream flow and at 300 mm below the surface of the water for collection. For biological analysis, sterilized 25-ml bottle was used. For the borehole, each water sample bottle was placed vertically under the tap to collect water directly as it was pumped from the borehole. Minimal air space was left in each bottle to allow for expansion, except the water samples for biochemical oxidation demand (BOD) and dissolved oxygen (DO) determination. Stream samples were collected at four different points along the stream subreach. To ensure that changes in sample properties did not occur while in transit to the laboratory, the bottles were placed in a cooler box, and appropriate preservation methods were applied prior to laboratory analysis of samples (Ademoroti, 1996). For DO and BOD testing, samples were collected in 150-ml bottles.

Chemical analysis

The DO sample was fixed with 2 ml each of Wrinkler I and II reagents at site, while BOD_5 sample bottles were corked and wrapped with aluminium foil and the BOD_5 sample was fixed with the Wrinkler method after five days incubation at room temperature (25°C) in the dark place. Acidity and alkalinty were determined by titration methods. Dissolved oxygen was determined using dissolved oxygen meter; BOD_5 was determined using BOD_5 Track; electrical conductivity was measured by electrical conductivity meter – DIST3 by HANNA limted. Ammonia – Nitrogen (NH_3-N) was determined by direct Nesslerization for natural effluent and Nitrate – Nitrogen (NO_3-N) was determined by the Brucine method (NWRI, 1997; Ademoroti, 1996; APHA, AWWA, WPCF, 1998). Their absorbance values were read with UNICAM 8626 UV/VIS spectrophotometer at 470 nm for NO_3-N and PO_4 and 420 nm for SO_3 ions (Ademoroti, 1996). Detection of coliform bacteria was done by pour plate technique in McConkey agar medium following incubation period of 18 to 24 h at 35 to 37°C and was determined in most probable number (MPN).

The chemical composition of the polluted soil around the facility borehole was analyzed using soil extract recovered from air-dried soil by the water extraction method (Spychalski et al., 2008). 60 g of an air-dried soil sample of the bush fallow floor was mixed with 60 ml of de-ionized water (that is. 1:1 mixed ratio) and shaken in a rotary shaker for 1 h, then centrifuged for 30 min at 5000 rotations (Spychalski et al., 2008). The soil extract was filtered through a 0.45-µm filter and stored at 4°C for analysis. The composition of the extract was determined by using ion chromatography; and was correlated with those of stream and borehole water to identify pollution source/effect on the water sources. (The 1:1 ratio of 60 g soil: 60 ml distilled water made the unit conversion from mg/L of solution to mg/kg of soil easier). Phosphates in water samples used titration with vanadate-molybdate reagent and the UNICAM 8625 UV/VLS spectrometer instrument to read the absorbance at 470 nm. The phosphate in soil extract used the Bray method (soil testing laboratory, 2007; Faithful, 2002).

The physico-chemical properties of abattoir waste water, as a particular organic pollutant, and those of the soil samples within the borehole location were correlated with surface and ground water properties, respectively, to relate the routes of impairment of water quality. Comparison or compatibility of water sample quality with WHO and other standards established the level of quality impairment or toxicity in water sources.

Table 1. Comparative physical – chemical properties of stream water and ground water at Uyo cattle market/slaughter.

Property	Stream water	Borehole	t-value
pH	6.27 ± 0.06	5.73 ± 0.07	93.5318**
EC (mS/cm)	60.13 ± 0.15	10.43 ± 0.59	141.519**
Acidity (mg/L)	29.42 ± 0.69	27.5 ± 1.17	4.091*
Alkalinity (mg/L)	40.50 ± 1.55	30.73 ± 0.43	16.888**
SO_4 (mg/L)	0.03 ± 0.01	0.05 ± 0.01	5.500
NO_3 (mg/L)	0.07 ± 0.01	0.15 ± 0.11	1.316
NH_4 (mg/L)	10.01 ± 0.01	0.02 ± 0.01	2.00
PO_4 (mg/L)	8.33±0.10	0.045±0.01	-
DO (mg/L)	3.43 ± 0.49	4.10 ± 0.10	2.250
BOD_5 (mg/L)	3.17 ± 0.02	2.63 ± 0.15	6.952*

*,** Significant at $p < 0.05$ and $p < 0.01$.

Data analysis

Relevant descriptive and inferential statistics were used to analyze the water parameter in the various sources for comparison. Statistical package for the social sciences (SPSS) ver. 17 package was employed for statistical computations. Correlations between different sources of water pollution and parameters of water sources were made. Also, percent compatibility of borehole water with the maximum permissible values of the Nigerian standards for drinking water quality (NSDWQ) and WHO was made as follows:

$$\% \text{ compatibility of pH} = \text{sample pH} \times 100/6.5 \quad (1)$$

$$\%\text{compatibility of other parameters} = 1 - \left(\frac{\text{sample parameter value}}{\text{NSDWQ value}}\right)100 \quad (2)$$

where parameters with NS (not detected) and 0 are assumed 0% compatible, since they are assumed as rarely existing, while parameter value which was equal to NSDWQ value was 100% compatible (NWRI, 1997).

RESULTS AND DISCUSSION

Physico-chemical properties of borehole and stream water

The physico-chemical properties of these water samples were compared between the two sources and with WHO standards for safe water. Table 1 shows the physico-chemical properties of the borehole and stream water samples. Borehole water was more acidic (5.73 ± 0.07) than stream water (6.27 ± 0.06). Electrical conductivity (EC) was 10.43 ± 0.59 mS/cm in borehole water; about six times lower than its value in stream water. The pH and electrical conductivity of water have some influence on the life of living organisms. The pH affects the growth of crop, nutrients availability in soil and general performance of microorganisms. It also affects the toxicity of inorganic pollutants such as nitrate and sulphate especially to fish and humans (Afia, 1998; SMART, 2007a; USEPA, 2009). Comparing the mean pH of the two water sources showed that their pH level was between 6.0- 8.5, within the range of standard limit for safe drinking water by WHO (1993). Electrical conductivity is controlled by concentration of dissolved salt which increases with silica, magnesium, potassium and carbonates. The high electrical conductivity in stream compared to borehole water indicates that borehole water was purer than stream water since pure water, like distilled water, is considered a weak electrolyte with a high resistance to the flow of electricity and consequently it has a low electrical conductivity (Bhattacharya and Michael, 2003; SMART, 2007b). Comparing these values with 40 mS/cm, which is the drinking water standard by WHO (1993), borehole water proved better quality for drinking and irrigation than stream water. Thus, organic waste accumulation in the cattle market/ slaughter lot surroundings had effect on the water quality of the stream with regards to concentration of dissolved salt.

Furthermore, no significant difference was observed in acidity level of borehole water (27.51 ± 1.17) mg/L and stream water 29.42 ± 0.69 mg/L ($p < 0.05$); which values were lower than 1369 mg/L obtained from msw dumpsite by Rattanaoudom (2005). The low acidity suggests that some waste materials may have produced alkaline materials which acted as buffer, hindering the solution (water) from changing the pH (Rao, 2004). This also reflected in the low alkalinity though, in their case, concentrations were significantly different: (30.70 ± 0.42 mg/L compared to 40.50 ± 1.35 mg/L ($p < 0.01$) for borehole and stream water, respectively. However, the values fell within acceptable range of 30 – 50 mg/L $CaCO_3$ by FEPA (1991). The stream water, with higher alkalinity, is good for irrigation since it could increase the base content and reduce the acidity level of the irrigated

Table 2. Compatibility of stream and borehole water quality with WHO standards at cattle market/slaughter, Uyo.

Properties	Stream water	Borehole	Standard used*
pH	3.5, 8.7	11.8, 32.6	6.5-8.5
EC (mS/cm)	-50.3	73.9	40.0
Acidity (mg/L)	41.2	45.0	50.0
Alkalinity (mg/L)	-35.0, 19	-2.4, 38.5	30.0, 50.0
SO_4 (mg/L)	100.0	100.0	250.0
NO_3 (mg/L)	99.3	98.5	10.0
NH_4 (mg/L)	0	100.0	0
PO_4 (mg/L)	16.7	99.6	10.0
DO (mg/L)	42.8	31.7	6.0-8.0
BOD_5 (mg/L)	20.7	34.2	4.0

*Selected from Food Environment Protection Act (FEPA), 1991; World Health Organization (WHO), 1993; Environmental Protection Agency (EPA), 2009.

soil (George, 1983; Ayers and Westcot, 1994; Bhattacharya and Michael, 2006; SMART, 2007c).

Concentration of total dissolved oxygen (DO) is also shown in Table 1. Borehole water had slightly higher dissolved oxygen (4.10 ± 0.10mg/L) than stream water (3.43 ± 0.49 mg/L). There was no significant difference in DO content of the two water sources ($p < 0.05$). Comparing the values with the standard (6-8mg/L) by WHO (1993), these water sources had low content of dissolved oxygen, which suggests that the water may be suitable for drinking but may not be suitable for aquaculture because it may increase biochemical activities in the pond (Ekweozor and Agbozu, 2001).

Values for sulphate were 0.05 ± 0.01mg/L in borehole water and were not significantly different from 0.03 ± 0.01mg/L in stream water ($p < 0.05$). Both values were lower than the WHO standard level of 2.00 – 4.00 mg/L (FEPA, 1991; WHO, 1993). The presence of sulphate increases the alkalinity content of the effluent receiving water (Rao, 2004), hence the low sulphate content in the stream water is reflected in the alkalinity level.

Mean nitrate in borehole water (0.15 ± 0.11 mg/L) was higher than that of stream water (0.07 ± 0.01 mg/L) but the difference was not significant ($p<0.05$). However, both values were lower than EPA's 10 mg/L (USEPA, 2009), or (50 mg/L) WHO standard level for safe drinking water (WHO, 1993). The low concentration of nitrogen in stream may be due to sulphide, which is highly volatile in nature and could escape by volatilization, whereas the concentration in borehole which is below EPA maximum critical level (MCL) may be due to its drastically reduced concentration at the 20 cm depth and lower profiles, arising from effective absorption by buffer plant roots.

Concentration of ammonia was 0.02 ± 0.01 mg/L in borehole water and 10.01 ± 0.01 mg/L in stream water (Table 1). There was a significant difference between them ($p<0.05$). Comparing these values with WHO standard limits, it may be inferred that, in relation to ammonia content, only borehole water was within the acceptable range. However, the level of ammonia in stream was increased by the cattle herders activity and cattle dung that have by-passed the cattle market/slaughter premises to the stream. This calls for a properly fenced pen for the cattle. With the present concentration of NO_3 and NH_4, the prospect of eutrophication is feasible especially if abattoir waste water were to cascade into the surface stream directly. Hence, there is need for physical buffer against direct influent of abattoir waste water to the stream (Osmond et al., 2002; Jontos, 2004). Phosphate in borehole water was within safe level by WHO; however, the level in stream water was only 17% less than the EPA limit of 10mg/L, which shows low compatibility with WHO limit (Table 2).

Biochemical oxygen demand (BOD) is also shown in Table 1. Borehole water had 2.63 ± 0.15 mg/L, lower than stream water (3.17 ± 0.02mg/L). BOD shows the extent of oxygen consumed by micro-organisms in decomposing organic constituents of the waste. This may be responsible for the low DO observed in these water sources. The values showed low compatibility with 4.0 mg/L standard for suitable drinking water.

Compatibility with WHO standards and others

In order to ascertain if the stream and borehole water quality was within the limit of safety for drinking and was within the maximum tolerance level, compatibility tests with WHO (1993) standards, NSDWQ (Nigerian standard for drinking water quality), FEPA (1991) and EPA (2009) standards were carried out. Table 2 indicates the results

Table 3. Paired-samples statistics test and correlation for water and pollution sources at cattle market/slaughter, Uyo.

Paired-Sample	Paired-sample correlations			Paired t-test		
	N	Correlation	Sig	t	Df	Sig. (2-tailed)
Stream/borehole water	9	0.688	0.041	1.261	8	0.243
Stream/abattoir waste water	9	0.402	0.283	-1.912	8	0.092** ($p<0.10$)
Stream/buffer soil solution extract	5	0.318	0.602	-1.952	4	0.123** ($p<0.10$)
Borehole/buffer soil solution extract	5	0.325	0.593	-2.067	4	0.108**($p<0.10$)

** Significant at 10%, N is number of tests.

Table 4. Comparison of stream water quality with polluting abattoir waste water at cattle market/slaughter microwatershed, Uyo.

Property	Stream water	Abattoir waste water	t-value
pH	6.27 ± 0.06	7.3	
EC (mS/cm)	60.13 ± 0.15	1648.0	-1.912**
Acidity (mg/L)	29.42 ± 0.69	80.0	
Alkalinity (mg/L)	40.50 ± 1.55	135.0	
SO_4 (mg/L)	0.03 ± 0.01	114.0	
NO_3 (mg/L)	0.07 ± 0.11	288.5	
NH_4 (mg/L)	10.01 ± 0.01	98.2	
PO_4 (mg/L)	8.33±0.10	284.1	
DO (mg/L)	3.43 ± 0.49	5.2	
BOD_5 (mg/L)	3.17 ± 0.02	1630.0	
Coliform count/100 ml	59	350.0	

** Significant at 10%.

of the compatibility analysis for the stream and borehole water with those standards. Apart from alkalinity and electric conductivity which had either negative and/or low compatibility (0-40%), the level of compatibility of the parameters varied widely with the components while the negative values depended on the lower safe limits used.

Evaluation of interference on water quality

Paired-samples statistics test and correlations were performed to evaluate quality impairment by organic waste and polluted runoff from the cattle market/slaughter. Paired-samples correlation between stream and borehole water samples had significant correlation at 1% significant level but the paired samples t-test showed no significant difference ($p<0.01$) (Table 3), indicating that both sources of water were not significantly different ($p<0.01$) in quality. Since compatibility with WHO was high only for some properties (Table 2), despite the NPS pollution from the cattle market/slaughter, interference with the water quality was varied but not significant or did not significantly impair quality of both water sources with respect to organic element (NO_3, SO_4, PO_4, EC, DO and BOD_5). However, the compatibility of borehole water surpassed that of the stream water, suggesting that it had less interference from organic waste pollution.

The abattoir waste water and stream water properties were also analyzed with paired-samples t-statistics to determine any interference of the waste water on stream water quality. No significant correlation at 10% significance level existed between the stream and abattoir waste water, and there was negative significant difference ($p<0.10$) between them (Tables 3 and 4). This shows that unless some buffering structure existed, the abattoir waste water would impair stream water quality. Thus, the interference on the stream quality was minimized, perhaps, by the buffering effect of the existing natural bush fallow into which the abattoir waste water drained before reaching the stream.

Thus, a proper designed natural vegetation riparian buffer is of tangible benefit to sustain the quality of stream water from being polluted by waste water and NPS runoff from the cattle market/slaughter. Also, paired-samples t-statistics correlated the samples of bush fallow soil solution extract (ME) and the stream water. No significant correlation ($p<0.10$) was observed between them, showing that the bush fallow filtered out much pollutant from the abattoir waste water and NPS runoff from the cattle market/slaughter which resulted in high pollutant particulates/nutrient on its soil, thereby leaving the adjoining stream water quality protected. Therefore, the bush fallow acted as natural vegetation riparian buffer to reduce pollutants movement from reaching the surface water; such riparian buffer has been shown to control nonpoint source pollution by intercepting surface runoff and subsurface flow, thereby controlling the nonpoint source pollution by removing nutrients especially nitrogen in nitrates, (NO_3-N, NH_4-N), phosphates and sediment (USDA, 1997; Lowrance et al., 1989; Osmond et al., 1995; Jontos, 2004; Wikipedia, 2011).

The prospect of organic pollutant in diffuse flow infiltrating into the soil within the borehole cone of depression and leaching to pollute the borehole water at depths was also analyzed with paired samples t-statistics. No significant correlations was observed between the borehole water sample and soil solution extract at 0-20cm depth in the buffer soil at the border between the market and the buffer where the borehole was constructed. Also, significant difference ($p<0.10$) in t-statistics existed between them (Table 3), showing that pollutants leached into the topsoil at the cattle market dumpsite and the buffer soil, but could not migrate to pollute the ground water. It is possible that the plant roots in the bush fallow absorbed the high nitrate in the NPS runoff and abattoir waste water for use in plant growth or, more importantly, provided an energy source for bacteria to converts nitrogen in nitrate to gas, which then escape to the atmosphere (that is denitrification), thereby reducing the pollution load that could be transported to ground water. This resulted in a reduced nitrate concentration in borehole water (Osmond et al, 2002). The moist condition of the soil at the cattle market dumpsite and abattoir, and acidic soil nature (Douglass, 2010) would have helped its capacity to take up nitrogen from the soil and release it to the atmosphere (through denitrification) (Hawes and Smith, 2005).

Implication to environmental management site design

The pollution of surface water (stream in this case) by organic waste effluent is not a significant problem compared to ground water pollution. An unusual site design, like inadequate soil cover, topography and hydrology, may cause leachate to exit the market with high pollutant concentration. Under such condition, the mixing of the concentrated waste with stream water may cause severe pollution of the stream which may lead to eutrophication. However, the riparian bush fallow significantly reduced the high concentration of abattoir waste water from direct entry to and pollution of the stream, in addition to possible denitrification by its roots, which also saved the rural borehole water from pollution at the facility. Therefore, properly upgraded bush fallow or designed natural vegetation riparian buffer is recommended.

Drainage system

If this water is allowed to infiltrate into the layers of waste heap, the water will seep through the ground and contaminate the soil beneath if there is no proper drainage system. Therefore, proper drainage system is recommended. This include arterial drains in the market ground; improvement of the bush fallow as a riparian buffer filter or using bio-filters; and constructing detention ponds downstream for drained surface water from the market to settle out the solids before overflowing to the buffer filter strip.

Prospect for irrigation application

The stream water, with alkalinity of 40.50 mg/L, EC of 60.13 mS/cm and sulphates of 0.03 mg/L, is good for irrigation application and is in suitability class I for irrigation water (Nathanson, 2006). The EC of 60.13 mS/cm and SAR < 10 for the stream water confirms the stream water is not saline; hence, it is suitable for continuous use in crop irrigation in the interfluves of the drainage river tributaries (Ayers and Westcot, 1994).

Other water quality classification

Using the water quality criteria of CPCB (1979) for water (freshwater) classification, the stream water belongs to class C freshwater. Class C freshwater by CPCB (1979) criteria should have DO ≥ 4 mg/L, BOD ≤ 3 mg/L, coliform (MPN)/100 ml ≤ 5000 and pH ≥ 6.0 – 9.0. This is not a suitable quality for drinking water (WH0, 1993; EPA, 2009). Therefore, the stream can be classified or zoned into designated-best use class C for freshwater (CPCB, 1979), that is, drinking water source with conventional treatment followed by disinfection. This is preferable, as it may be used in future for supplementary urban source of drinking water supply under the on-going urbanization expansion and renewal activities. This (best-use) plan requires that effluent water treatment must be put in place, such as designing the hydrology and the width of the natural vegetation riparian buffer, to improve its present level of effectiveness of sediment filtering (Lowrance et al., 1995; Allison and Dhakal, 2000; Daniels and Gilliam, 1996; Dillaha and Hayes, 1991).

Alternatively, however, the present ground water quality is good enough for a class C source of water (CPCB, 1979), except that its pH is significantly higher than the pH of 6.0 – 9.0 for C fresh water. This should be addressed for the sake of the health of the traders, travelers and residents or squatters on and around the cattle market vicinity. A borehole for drinking water can be drilled at upslope of the riparian area of the market and made deeper than presently is.

Conclusion

Stream and ground water quality at the vicinity of suburban cattle market/slaughter was assessed against possible interference on them by polluted NPS runoff and abattoir waste water from the organic waste on the market/slaughter ground. Standard methods were applied to analyze the water quality parameters. The quality was statistically analyzed using SPSS ver 17 package. Water quality was statistically compared with abattoir waste water and soil extract solution for cause/effect of pollution. The impairment of quality (if any) was evaluated against WHO and national water quality standards using percentage compatibility and correlation analysis. Significant difference ($p<0.01$) was not observed between stream and ground water despite organic waste proximity; however, wide compatibility with water quality standard were recorded for some water properties. Also, significant difference existed between abattoir waste water and stream water and between ground water and soil extract solution, showing that the water sources may have been buffered from polluting concentrations of organic waste; and made safe for drinking, washing and irrigation conjunctive uses, possibly by on-site bush fallow riparian buffer. It is recommended that the present bush fallow be upgraded or designed into a natural vegetation riparian buffer to effectively protect stream/ground water from the polluting effect of the organic waste effluent and waste water on a sustained basis.

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