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Environmental Implications of Animal Wastes Pollution on Agricultural Soil and Water Quality

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Abstract

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An attempt was made to ascertain the environmental effects of animal wastes pollution on agricultural soil and water quality at the oldest teaching and research farm, Federal University of Technology, Akure, Nigeria. Physical, chemical, and bacteriological analyses of water (shallow well) and soil samples were carried out to determine the present quality status. Fifteen soil samples collected at the centre of the animal wastes dump and at a distance of 5 and 10 m, and three different samplings done on the water source were analyzed. The parameters determined using APHA standard procedures included: turbidity, temperature, pH, alkalinity, sulphide, phosphate, dissolved oxygen, total dissolved solids, total hardness, biochemical oxygen demand, total iron, nitrate, chloride, calcium, and heavy metals like copper, zinc, and lead. Most of the parameters indicated pollution including heavy metals presence with the exception of Pb, Zn, Mn, Cu, and Cr that were not detected in water samples. Concentrations of nitrate, biochemical oxygen demand, SO_4^{2-}, PO_4^{3-}, and Cl^- were 0.20, 3.20, 10.50, 3.5, and 20.4 mg/l respectively, while those of detected heavy metals such as Mg and Ni were 1.98 and 10.03 mg/l, respectively. Soil water holding capacity, porosity, pH, organic matter, organic carbon, and organic nitrogen ranged from 33.34 ± 3.73 to 59.06 ± 5.69, 34.6 ± 3.28 to 52.43 ± 5.5, 6.56 ± 0.03 to 7.54 ± 0.03, 2.32 ± 0.03 to 5.35 ± 0.03, 1.33 ± 0.01 to 3.11 ± 0.01, and 0.58 ± 0.07 to 1.13 ± 0.03%, respectively. The results showed that the well is strongly polluted with bacteria and pathogens and requires considerable treatment before use while the soil is suitable for crop production.

Keywords: animal; pollution; soil; water; wastes

The extent of deterioration of soil and water resources due to pollution has assumed a frightening dimension with its attendant effects on global food security, water quality and hygiene and sustainable livelihoods. The downside of utilizing these essential resources is the occurrence of water contamination resulting from its many and varied uses (Akinbile & Ogedengbe 2004). Agriculture alone is the leading source of decreased water quality in both lakes and rivers, and the third largest contributor to estuarine habitat degradation (USEPA 2007). Overland flow from agricultural lands contain nutrients, sediments, pesticides, salts, and animal wastes and the effects of such materials entering into receiving waters include both decreased water quality as well as riparian habitat losses (Adekunle *et al.* 2007). As livestock operations continue to expand, farm owners are constantly dealing with the issue of animal waste management with its associated challenges, especially disposal, in developing countries (Akinbile & Ogedengbe 2006). Livestock operators have been land applying manure for centuries to supplement soil nutrients for crop use. This was done to manage large volumes of animal wastes and also to reduce the amount of

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synthetic fertilizers that must be purchased and applied to crops for achieving higher yields (Akinbile & Ogedengbe 2006). The bacterial contamination of groundwater (via leaching or seepage) and surface waters receiving runoff from such lands is a major health concern (Atiribom *et al.* 2007).

There are variety of uses for animal wastes including a fuel source, animal bedding, animal feed, mulch, organic matter, and plant nutrients (Schwartz *et al.* 2000) since land application of animal wastes is a common method of utilization. Depending on water content, incorporation of animal waste into the soil profile can be met with multiple benefits which include improvements in soil tilt, water holding capacity, and aeration. These are all reported advantages of manure addition to the soil (Adekunle *et al.* 2007). Also, land-applied manure can increase soil resistance to both wind and water erosion while organic material contained within the waste can improve soil structure as well as infiltration capacity of soil (EPA 2005). Enhanced fertility of the receiving soils is credited to the nutrients present in the animal waste material. As the animal wastes are degraded by indigenous microorganisms, nutrients are slowly released. This slow release conserves the nutrients and allows them to be available to the crop throughout the growing season. However, since the rate of such releases is uncontrollable, this can be viewed as a disadvantage as well (Fučík *et al.* 2008). Finally, the economic value of manure can be determined by its nutrient content (N, P, and K) and the material can be sold as commercial fertilizer. Therefore, the objectives of this study are to assess the impacts of animal wastes pollution on agricultural soil and water quality and to recommend the best management practices (BMPs) which would curtail the trend and would be beneficial to the environment.

MATERIAL AND METHODS

Description of the study area. The teaching and research farm of the Federal University of Technology, Akure (FUTA), Nigeria is located along Malu road (9°18'N, 5°8'E). The farm has different sections (feed mill, cattle, brooding, poultry, and piggery). The farm is located near the staff quarters and postgraduate hostel. FUTA is located in Akure, capital city of Ondo State, south western Nigeria (7°58'0"N, 8°46'0"E). Akure has a tropical humid climate with two distinct seasons, a relatively dry season from November to March and a wet/rainy season from April to October. Average annual rainfall ranges between 1405 and 2400 mm of which the rainy season accounts for 90% while the month of April marks the beginning of rainfall (Akinbile 2006). High temperature and high humidity also characterize the Akure climate which is influenced by the rain-bearing southwest monsoon winds from the ocean and the dry northwest winds from the Sahara desert. Atmospheric temperature ranges between 28 and 31°C and mean annual relative humidity is about 80% (Akinbile 2006). The soil is made up of ferruginous tropical soils (Ibitoye 2001). Crystalline acid rocks constitute the main parent material of these soils. The main features include a sandy surface horizon underlain by a weakly developed clayey, mottled, and occasionally concretionary sub-soil. The soil is however sensitive to erosion and occasional water logging as a result of the clay sub-soil. The soils have an exceptional clayey texture, but combine good drainage and aeration with good properties of moisture and nutrient retention (en.wikipedia.org/wiki/Akure).

Animals housing and generated wastes. Cattle section is housed by 251 animals (10 per unit), fowl section enrolls 989 birds (mainly of layer species), and 39 animals are kept at the piggery section. The brooding section has well over 2810 chicks while the feed mill, located at 18 m west of the farm, produces the concentrates for fowls feeding. A total average of 680 g of wastes per unit is generated daily at the cattle section while 280 and 87 g are generated at the poultry and brooding sections, respectively. The wastes are removed daily from their respective sections and dumped nearby for ease of movement, being infiltrated into the soil with rainfall. The wastes are not tilled into the soil but merely surface dumped; unfortunately the cropping section is 1.4 km away from the animal farms. Students at all levels (undergraduate and postgraduate) scoop considerable quantities of this waste for various analyses while farmers near the University community (with permitted access to the farm) usually take large chunk of it as farm yard manure (FYM).

The amounts of wastes generated daily in the respective sections were estimated as follows:

Cattle – one unit per 10 animals produces 680 g, waste production of 25 units = 17 000 g; pigs = 133 g; poultry (combined wastes – mature 280 g and brooding 87 g) = 367 g in total.

Total wastes generated daily in the animal farm = 17 000 + 133 + 367 = 17 500 g (17.5 kg).

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Water sampling and bacteriological analyses. Water samples were collected from the only available well located at about 5m away from the brooding section using a sterilized plastic bottle and refrigerated at 4°C in accordance with a standard procedure of APHA (2005) until the laboratory analyses. Physical parameters analyzed were odour, taste, colour, turbidity, and temperature. Chemical parameters analyzed were pH, dissolved oxygen (DO), total dissolved solids (TDS), total hardness (TH), total iron, nitrate, nitrite, chloride, calcium, and heavy metals such as copper, lead, and zinc. A bacteriological analysis was also carried out to ascertain the total coliform counts, *Escherichia coli* (*E. coli*) counts, and faecal coliform counts.

HI9828 Multiparameter water quality meter (Hanna Instruments, Capodistria, Slovenia) was used to measure *in situ* DO, biochemical oxygen demand (BOD), electrical conductivity (EC), TDS, and temperature while the heavy metals were determined using an atomic adsorption spectrophotometer (AAS) (Shimadzu AA-7000 series, Kyoto, Japan). Physical parameters such as odour, colour, and taste were at the discretion of the researcher after conducting physical examination on the samples, other parameters such as NO_2, NO_3, Cl, and Ca were determined using standard laboratory procedures according to APHA (2005), and a turbidimeter (Hanna Instruments) was used for turbidity measurement. Bacteriological assay was used in determining *E. coli* and faecal coliform in the water samples (Osuinde & Eneuzie 1999).

Soil sampling and analyses. 500 ± 0.5 g of soil samples were collected from each of the five sections of teaching and research (T&R) farm for analysis. The sections were goat and sheep, cattle, poultry, piggery, and feed mill, at a depth of 30 cm and distance 0, 5, and 10 m respectively per sampling point at each section's dumpsite. The samples were air dried, sieved using a 2 mm mesh and stored in sampling bags for analysis and the following constituents were analyzed: pH, organic matter (OM), organic content (OC), nitrogen (N), phosphorus (P), calcium (Ca), magnesium (Mg), copper (Cu), lead (Pb), sodium (Na), and potassium (K). This was done using standard laboratory procedures and analytical methods (APHA 2005). The pH was measured using a pH meter (Mettler Toledo, Columbus, USA) and the soil organic content was determined in the laboratory using a muffle furnace to burn the soil at 440°C for 24 h. The soil porosity, moisture content and water holding capacity were also determined in the laboratory using standard procedures (Ibitoye 2001). The physical properties such as moisture content (MC), water holding capacity (WHC), porosity, particle size, and bulk density (BD) were also analyzed. The values were compared with the Food and Agriculture Organization (FAO) standards permissible for ideal agricultural practices and World Health Organization (WHO) values for water quality.

Statistical analysis. Results obtained were subjected to statistical analysis using the SPSS software, Version 19, the descriptive analyses and the analysis of variance (ANOVA), least square significance (LSD) and Duncan's Multiple Range Test (DMRT) at $P < 0.05$ significance levels.

RESULTS AND DISCUSSION

Water analysis

Physicochemical properties of the water samples. Table 1 shows results of the physicochemical analysis carried out on the only shallow well water in the farm as compared with the standard FAO and WHO guideline values. With the exception of EC, PO_4, and SO_4 (as in the case of FAO values), all other parameters considered were within permissible limits of the two regulatory bodies. EC value was 9.6×10^2 (µs/cm) which affirmed the presence of conductive ions in solution according to WHO (2004). PO_4 value of 3.5 mg/l was higher than the values of 0.3 mg/l recommended both by FAO and WHO. Phosphate itself has no notable adverse health effects but when present in quantities above the recommended value, it stimulates algae and weeds growth wildly and quickly (Rejšek 2006). Sulphate (SO_4) value of 10.5 mg/l falls within the recommended guideline of the WHO but fails to meet the requirements of FAO. High concentration of SO_4 in drinking water could result in diarrhea, dehydration or weight loss (Akinbile 2006) and could also result in noticeable taste or corrosion of water distribution systems (Akinbile 2012). Values for colour and taste were subjectively determined and found to be in line with the recommended FAO (2007) values. Coloured water is an indication of pollution and confirmed the presence of dissolved and suspended particles (Akinbile & Ogedengbe 2004), manganese or substances of vegetable origin such as algae and weeds. Turbidity values of 0.02 NTU, which is far below the guideline values, were recorded due to the presence of suspended solids and colloidal

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mater caused by dredging or due to the growth of micro-organisms. High turbidity levels can reduce the amount of light reaching lower depths, which can inhibit growth of submerged aquatic plants and consequently affect the ability of fish gills to absorb dissolved oxygen (EPA 2005). At no time can turbidity (cloudiness of water) go above 5 nephelometric units (NTU) (USEPA 2007). The water pH value is 6.70 which falls within the range of WHO and FAO permissible values (6.0–8.5 and 6.5–8.5 respectively), it is acidic (indicating the presence of metals, though a number of metals (such as lead, copper, manganese, chromium iron, and zinc) were not detected), and thus it is tolerable for municipal and domestic use (Friedlová 2010). The tolerable pH limit for fish and other aquatic animals is 9.0 above which the BOD_5 and DO would be reduced thereby endangering the aquatic lives. The pH findings from this study agreed with the values obtained by Akinbile (2012). Values of 9.5 and above indicate high alkalinity while values of 3 and below indicate acidity. Low pH values help in effective chlorination but cause problems with corrosion. This indicates that the well water is slightly polluted and will require minimal treatment to attain level permitting human and animal consumption (especially due to the presence of EC and PO_4 which could increase chances of abortion in crops), but the water source is now applicable for irrigation purposes.

Table 1. Physicochemical parameters of water sample analyzed with WHO and FAO standards (unless otherwise stated, all values are in mg/l)

Parameters	WHO	FAO	Well Water
Colour	colourless	colourless	clear
Odour	odourless	odourless	mild
Taste	tasteless	tasteless	tasteless
Temperature (°C)	25	25	25
pH	6.0–8.5	6.5–8.5	6.70
Turbidity (NTU)	0.5–5	5.0	0.02
Alkalinity	100	200	23.00
EC (μs/cm)	300	3.0	960
DO	0.3	2.0	7.80
BOD_5	5.0	10	3.20
Cl^-	200	2000	20.40
NO_3	50	30	0.20
SO_4	150	0.05	10.50
TSS	10	20	19.37
TS	500	100	31.60
TDS	0.5	30	12.23
TH	200	200	22.00
PO_4	0.3	0.3	3.5

NTU – nephelometric turbidity unit; EC – electrical conductivity; DO – dissolved oxygen; BOD – biochemical oxygen demand; Cl^- – chloride; TSS – total suspened solids; TS – total solids; TDS – total dissolved solids; TH – total hardness

Table 2. Heavy metals in comparison with WHO and FAO standards (in mg/l)

Parameter	WHO	FAO	Well water
Fe	0.5–50	0.5–50	–
Zn	3.0	3.0	–
Ni	0.02	0.02	0.03
Pb	0.01	0.01	–
Cu	1.0	1.0	–
Mn	0.5	0.5	–
Mg	150	–	1.98
Cr^{3-}	0.05	0.05	–

– not detected

Presence of heavy metals in the water samples. Table 2 contains the results of heavy metals analysis of water from the shallow well in the farm. Out of the eight heavy metals investigated in the water samples, only two (Ni and Mg) were detected and their concentrations were well below the guideline values of both the FAO and WHO. Other metals, such as Pb, Cu, Zn, Fe, Mn, and Cr, were not present at all in the water samples meaning the water is non-toxic or does not contain poison (absence of Pb), no underlying rock formation near the well location (Cr, Cu, and Mn) and no disposal near the farm.

Bacteriological analysis of the water samples. The results of bacteriological assay of the farm water samples are presented in Table 3. Very high values of total coliform, faecal coliform, and *E. coli* were recorded which gave credence to the fact that the water is severely polluted with bacteria infested

Table 3. Bacteriological analysis in comparison with WHO and FAO water standards (in 1/100 ml)

Parameters	WHO	FAO	Well water
Total coliform	0	1	200
Faecal coliform	0	0	120
Eschericha coli	0	1	11.60

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materials. The high values could be attributed to the dumping of animal waste directly on the soil surface. During rainfall, these pathogens, microorganisms are washed into the well either through the little openings between the lined materials, by infiltration, percolation and seepage (Osuinde & Eneuzie 1999). The result of the sample analyzed showed 200, 120, and 11.60/100 ml water for total coliform, faecal coliform, and *E. coli*, respectively. The values were far above 1/100 ml approved by the WHO guidelines for drinking water quality which indicate the presence of organisms from faecal material and intestinal pathogens. The huge presence of *E. coli* underscored its status as essential indicator of pollution by faecal material of human or animal origin. The *E. coli* count obviously emanated from the improper handling of the animal wastes in the farm in relation to its dumpsite located near the shallow well which negates Sangodoyin's (1991) postulation that a dumpsite like this should be located 30 m radially away from any water source.

Physicochemical analyses of the soil samples

Tables 4 and 5 showed the physical and chemical properties of the soil at different sections of the teaching and research (T&R) farm. Soil samples from all the sections were analyzed while the USDA textural triangle was used for classifying the soils and it was found to be sandy clay loam for all the sections (Table 4). The high value of sand in feed mill section accounts for reduction in the organic matter content (Table 5) and this could be attributed to the fact that there is no form of animal droppings in that section. Ibitoye (2001) made similar observations in his study which indicated a decrease in sand within the refuse dump area as the soil depth increased and no significant difference was observed ($P < 0.05$) within all the sections. The mean moisture contents for piggery, cattle, goat, and feed mill were 51.16 ± 3.25, 33.35 ± 0.71, 24.34 ± 1.7, 31.98 ± 2.34, and 31.68 ± 0.46%, respectively, meaning that MC decreased from the waste point with increasing distance at each location except feed mill and cattle sections where it was random and this could be attributed to the fact that there is no specific dump area for the cattle and no animal waste dump at the feed mill section. This is similar to the observations made by Molden (2007). The moisture content within the refuse and dump (centre) was higher as this was associated with the increased activity of organisms and high organic matter. The mean water holding capacity is 59.06 ± 5.69% for piggery section, 44.99 ± 1.76% for cattle section, 33.34 ± 3.73% for poultry, 40.09 ± 4.32% for goat and sheep, and 41.78 ± 1.3% for feed mill section. WHC was high due to high organic matter content in the soil samples at each location and clay content distribution though there was an exception at the poultry location which had the lowest WHC and this could be attributed to the soil structure and the terrain here. It was also noticed that during the sample collection in poultry section, the soil was more compacted than at the other places. Mean porosity values of the soil from piggery section, cattle section, poultry section, goat and sheep section, and feed mill section were 52.43 ± 5.5, 41.17 ± 1.03, 34.6 ± 3.28, 42.42 ± 1.53, and 42.61 ± 0.76%, respectively (Table 4). Porosity ranged from 34 to 58%, which indicates a high percentage

Table 4. Physical properties of soil samples analyzed at different locations (all values are in % except where otherwise stated)

Parameters	Locations				
	pig	cattle	poultry	goat and sheep	feed mill
Clay	32.6 ± 0.66^{b}	30.46 ± 0.9^{a}	29.73 ± 1.27^{a}	35.27 ± 1.2^{c}	32.54 ± 0.77^{b}
Silt	25.67 ± 0.58^{c}	20.37 ± 1.18^{b}	26.47 ± 2.16^{c}	20.73 ± 0.46^{b}	16.1 ± 1.15^{a}
Sand	42.43 ± 1.89^{a}	48.51 ± 0.96^{ab}	45.8 ± 6.39^{ab}	43.99 ± 1.65^{a}	51.36 ± 0.77^{b}
MC	51.16 ± 3.25^{c}	33.35 ± 0.71^{b}	24.34 ± 1.7^{a}	31.98 ± 2.34^{b}	31.68 ± 0.46^{b}
WHC	59.06 ± 5.69^{c}	44.99 ± 1.76^{b}	33.34 ± 3.73^{a}	40.09 ± 4.32^{ab}	41.78 ± 1.3^{b}
Porosity	52.43 ± 5.5^{c}	41.17 ± 1.03^{b}	34.6 ± 3.28^{a}	42.42 ± 1.53^{b}	42.61 ± 0.76^{b}
Bulk density (g/cm^3)	0.92 ± 0.07^{a}	1.25 ± 0.03^{b}	1.56 ± 0.1^{c}	1.19 ± 0.09^{b}	1.17 ± 0.02^{b}

MC – moisture content, WHC – water holding capacity; means in a given row with the same letter were not significantly different at $P < 0.05$

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of clay content for a low sand proportion. Poultry section has the highest mean bulk density and this could also be compared with the low porosity value of the soil at the same section. It was evident that the lower the porosity, the higher the bulk density and this can also cause water hindrance down the profile. Yusuf (2007) made similar observations in his studies and the compacted nature of the soil could also be the reason for the high value of bulk density.

Table 5 shows the chemical properties of the soil analyzed and the mean values of pH are 6.88 ± 0.03, 7.54 ± 0.03, 6.56 ± 0.03, 6.9 ± 0.03, and 7.42 ± 0.03 in all the sections, respectively. There were no significant differences between the samples from piggery and goat section which could be due to similarities in their feeds. For each of the section replicates, pH decreased with the increasing distance from the waste dump. This could be a result of high exchangeable bases content around the waste dump (Akinbile 2012). Mean values of nitrogen were 0.58 ± 0.07, 1.13 ± 0.03, 0.73 ± 0.05, 0.67 ± 0.02, and 1.13 ± 0.01% in all the sections respectively. There were no significant differences between the soil samples from poultry and goat sections but they were significantly different from those of the other three locations. Also, soil from piggery section was significantly different from the samples from the other locations. OM mean values were 4.27 ± 0.14, 3.33 ± 0.05, 5.35 ± 0.03, 3.99 ± 0.62, and 2.32 ± 0.03% for all the sections and it decreased with the increasing distance from the centre of the dump (CD). High OM around CD favoured increased MC, WHC, and permeability. Water is able to enter and percolate downward through the soil with pollutants (Rangwala *et al.* 2007). The levels of OM in other sections except feed mill were considerably high and this indicated the effect of animal waste on the soils around the feed mill where the animal waste dump is situated.

Mean values for organic carbon (OC) in all the sections were 2.51 ± 0.04, 1.92 ± 0.03, 3.11 ± 0.01, 2.51 ± 0.03, and 1.33 ± 0.01%, respectively (Table 5). Poultry has the highest OC value while the feed mill section has the least OC and the possible reason behind this could be that there is no animal wastes dump within the section. Nitrogen content decreased with the increasing distance from the waste dump with each location's replicates except for cattle and feed mill sections (Table 5). It was evident that there was no concentrated area for animal wastes dump as it was observed during sampling. This is similar to the findings of Akinbile (2012). Mean values for phosphorus concentrations at each location were 9.85 ± 0.04, 5.03 ± 0.03, 7.91 ± 0.03, 8.24 ± 0.09, and 3.54 ± 0.03 mg/kg, respectively and they decreased with the increasing distance from the CD and also for the replicates. For all the locations except the feed mill, high calcium content was observed. The reason could be the salt content in the animal concentrates. The mean values were 82 ± 3.00, 73.33 ± 1.53, 100.67 ± 2.52, 53.47 ± 1.75, and 12.29 ± 0.5 mg/kg respectively

Table 5. Chemical properties of soil samples analyzed at different locations (all values are in mg/kg except where otherwise stated)

Parameters	Locations				
	pig	cattle	poultry	goat and sheep	feed mill
pH	6.88 ± 0.03^{b}	7.54 ± 0.03^{d}	6.56 ± 0.03^{a}	6.9 ± 0.03^{b}	7.42 ± 0.03^{c}
Nitrogen	0.58 ± 0.07^{a}	1.13 ± 0.03^{c}	0.73 ± 0.05^{b}	0.67 ± 0.02^{b}	1.13 ± 0.01^{c}
OC	2.51 ± 0.04^{c}	1.92 ± 0.03^{b}	3.11 ± 0.01^{d}	2.51 ± 0.03^{c}	1.33 ± 0.01^{a}
OM	4.27 ± 0.14^{c}	3.33 ± 0.05^{b}	5.35 ± 0.03^{d}	3.99 ± 0.62^{c}	2.32 ± 0.03^{a}
EC (µs/cm)	89.33 ± 1.15^{c}	93.33 ± 1.15^{d}	86.67 ± 0.58^{b}	83.67 ± 1.15^{a}	86 ± 0^{b}
Potassium	16.63 ± 1.21^{c}	15.57 ± 0.4^{c}	19.22 ± 0.19^{d}	13.32 ± 0.33^{b}	11.27 ± 0.03^{a}
Sodium	11.16 ± 0.04^{b}	14.43 ± 0.4^{c}	10.94 ± 0.07^{b}	10.32 ± 0.25^{a}	10.08 ± 0.06^{a}
Calcium	82 ± 3^{d}	73.33 ± 1.53^{c}	100.67 ± 2.52^{e}	53.47 ± 1.75^{b}	12.29 ± 0.5^{a}
Magnesium	18.2 ± 0.3^{d}	16.01 ± 0.07^{c}	43.14 ± 0.31^{e}	15.17 ± 0.51^{b}	1.26 ± 0.02^{a}
Copper	1.24 ± 0.12^{c}	1.35 ± 0.06^{d}	1.13 ± 0.03^{b}	1.07 ± 0.04^{b}	0.24 ± 0.1^{a}
Phosphorus	9.85 ± 0.04^{e}	5.03 ± 0.03^{b}	7.91 ± 0.03^{c}	8.24 ± 0.09^{d}	3.54 ± 0.03^{a}

OC – organic carbon; OM – organic matter; EC – electrical conductivity; means in a given row with the same letter were not significantly different at $P < 0.05$

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Table 6. Correlation coefficient of different soil samples of chemical variables from the study data

Variable	pH	N	OC	OM	EC	K	Na	Ca	Mg	Cu	P
pH	1										
Na	0.86	1									
OC	–0.91	–0.79	1								
OM	–0.86	–0.71	0.97	1							
EC	0.48	0.39	–0.17	–0.08	1						
K	–0.63	–0.44	0.82	0.87	0.33	1					
Na	0.49	0.43	–0.11	–0.05	0.89	0.29	1				
Ca	–0.61	–0.53	0.86	0.88	0.35	0.96	0.37	1			
Mg	–0.77	–0.48	0.90	0.92	0.01	0.91	0.07	0.88	1		
Cu	–0.31	–0.43	0.65	0.64	0.49	0.71	0.60	0.85	0.56	1	
P	–0.80	–0.96	0.82	0.77	–0.16	0.58	–0.21	0.67	0.53	0.62	1

OC – organic carbon, OM – organic matter, EC – electrical conductivity

(Table 5) which also shows each location's mean values of other exchangeable parameters such as sodium, potassium, and magnesium. As for heavy metals, Pb was not detected at all, and just traces of Cu were found out at the five locations. Cu mean values were 1.24 ± 0.12, 1.35 ± 0.06, 1.13 ± 0.03, 1.07 ± 0.04, and 0.24 ± 0.1 mg/kg, respectively. Low values of heavy metals in all the sections indicate little or no toxic pollution and could be the reason why most of the heavy metals were not detected in the water sample analyzed from the same study area.

Correlations of physical and chemical parameters in all the sections

The significance of the observed correlation coefficients for chemical and physical parameters is shown in Tables 6 and 7, respectively. Out of a total 55 correlations found between two parameters at a significant level of 0.05, 14 were found to be significant at $R > 0.8$ which indicated strong correlations, two were found to be significant at $0.7 < R < 0.8$, eight were found to be significant at $0.5 < R < 0.7$ with four of them greater than five and less than six. Similarly, 20 negative correlations were also found (Table 6).

Table 7 shows that silt had a significant negative relationship with clay ($R= -0.27$) which menas that silt decreases as clay increases. Sand also had negative correlation coefficient between clay and silt (–0.36 and –0.72 respectively). MC had a low significant relationship between clay and silt (0.31 and 0.22 respectively) and a negative correlation between sand (–0.43). This is evident in that the moisture content lowers as sand increases. However, there was a high significant relationship between WHC and MC (0.97) which indicated an increase in MC when there was a corresponding increase in WHC. In all the parameters tested using *t*-test correlation analysis, there were

Table 7. Correlation coefficients of different soil samples of physical variables from the study data

Variables	Clay	Silt	Sand	MC	WHC	Porosity	BD
Clay	1						
Silt	–0.27	1					
Sand	–0.36	–0.72	1				
MC	0.31	0.22	–0.43	1			
WHC	0.26	0.17	–0.39	0.97	1		
Porosity	0.49	0.07	–0.42	0.94	0.95	1	
BD	–0.58	0.15	0.30	–0.90	–0.89	–0.95	1

MC – moisture content, WHC – water holding capacity, BD – bulk density

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significant differences considered at 95% confidence interval also confirming the presence of pollutants at irregular concentrations in all the soil samples.

CONCLUSIONS

A fundamental discovery from the study was that water from the shallow well serving the entire farm did not meet minimum requirements given by the WHO and FAO standards. It was also revealed that concentrations of animal waste materials in the study area had systematically increased some important soil nutrients as well as polluted groundwater over time. The effect of the pollution declined with distance from the polluting source which implied that contamination of groundwater was more dependent on the proximity to the dump sites. However, the results indicated very poor sanitation and damaging effects on the health of both humans and animals if the well water is used for domestic and agricultural purposes. Similarly, the effect of waste disposal on soils is damaging because when the chemical elements are absorbed by soils, toxins pass into the food chain through grazing animals which affects their productivity. Evidently, improper dumping of animal wastes should be discouraged, especially within the farm vicinity for healthy living of both human and animals and sustained productive use of soils for increased productivity. Urgent treatment of the well water before use and composting rather than indiscriminate dumping are to be encouraged for optimum crop production.

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