Environmental Audit of Integrated Farm Industry Settlement in Abeokuta, Ogun State, Nigeria

Akinsanmi Ogunyemi*, Olusegun Oguntoke and Oluwafemi Oyenekan

College of Environmental Resources Management, Federal University of Agriculture, Abeokuta, Nigeria

ARTICLE INFO

Received: 13 Jun 2017
Received in revised:
18 Oct 2017
Accepted: 31 Oct 2017
Published online:
4 Dec 2017
DOI: 10.14456/ennrj.2018.4

Keywords:
Environmental audit/ Integrated farm/ Standards/ Parameters/ Compliance/ Pollution

*** Corresponding author:**
E-mail:
essackyy2k3@yahoo.com

ABSTRACT

Environmental auditing is a necessary part of environmental management providing feedback mechanisms about overall environmental performance, and specific problem areas as well as corrective actions. This study assessed the pollution level and environmental performance of an integrated farm settlement which involved audit checklist administration and laboratory analyses of soil, sediment and water samples. Criteria parameters such as pH, temperature, total dissolved solids (TDS), electrical conductivity (EC), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate, phosphate, total nitrogen, and available phosphorus were determined in the media. Results showed that pH values ranged from 7.67-10.20, 9.06-9.82 and 8.9-9.27 in soil, water and sediment respectively. EC ranged from 59-450 µS/cm in soil, 106-277 µS/cm in sediment and 177-509 µS/cm in water and 643-814 in effluent. TDS ranged between 29 and 243 ppm in soil, 53-139 ppm in sediment and 90-252 ppm in water and 318-404 in effluent samples. Nitrate and phosphate concentrations in water samples ranged between 1.20-1.37 mg/L and 0.10-0.17 mg/L along with low BOD value which ranged from 0.70-1.20 mg/L while the COD value ranged between 32-382 mg/L. Total nitrogen and available phosphorus in sediment samples ranged from 0.32-2.85% and 46.3-112.3 mg/kg respectively. pH levels in water samples (PW and RP) were slightly above the WHO guideline while COD in effluent samples (HE and PE) exceeded NESREA limit. Environmental management practices were almost non-existent evidenced by resource wastage and lack of adequate waste management plan. Improved farm integration aimed at zero wastage should be adopted.

1. INTRODUCTION

Man depends more on farm produce as a source of food, but over the years there has been diverse improvement and modification in crop cultivation and rearing of animals. Due to the responsibility of meeting the food demand for ever increasing human population, improved methods and equipment have been devised for large scale farming. An integrated farming system consists of a range of resource-saving practices that aim at achieving acceptable profits with high and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment (Antonio and Silva, 2010). In an integrated system, livestock and crops are produced within a coordinated framework (VanKeulen and Schiere, 2004) with enormous benefits. The waste products of one component serve as a resource for the other. For example, animal manure is used to improve soil fertility, reducing the use of chemical fertilizers and enhancing crop production while crop residues and by-products feed the animals thereby supplementing often inadequate feed supplies. This contributes to improved animal nutrition and productivity.

Although increase in demand for crop and livestock products presents opportunities for small-scale farmers who can increase production and benefit from related income (Delgado et al., 2001), the growth in agricultural production can have a negative impact on man and natural resources. The quality of the environmental media (soil, water and air) could be affected by farm production processes, chemical utilization, materials and other equipment used in increasing farm industry productivity so as to meet the needs of the increasing population. According to Doom et al. (2002), industrial farms are leading producers of noxious substances such as nitrous oxide and ammonia while some regional farms alone produce more than 400 different gases, in addition to dust and airborne particles. Airborne particles also known as endotoxins are generated during the handling and disposal of manure, in the production and use of animal feeds, and the shipping and distribution of farm products (Hoff et al., 2002). Production of vast crops required for animal feed also pollutes the air and soil, especially with the use of synthetic fertilizers that were responsible for 68% of all nitrous oxide released into the atmosphere in 2004 (USEPA, 2015). A study found that there was a significant prevalence of asthma in children at a school near a CAFO (concentrated animal feeding operation) compared to those that are not (Sigurdarson and Kline, 2006).

Fertilizers often contain ammonium nitrate (NH_4NO_3), phosphorus as P_2O_5, and potassium as K_2O, some of which are quite stable and their bio-degradation may take weeks and even months. Since they are not degradable, their accumulation in the soil above their toxic levels due to excessive use becomes an indestructible poison for crops. The use of pesticides to control pests such as insects, fungi, bacteria, viruses and rodents could have toxic effects on human and animals and decreases in soil fertility. Eutrophication depletes or reduces the dissolved oxygen required for the survival of other beneficial aquatic organisms, usually triggered by the excessive utilization of fertilizers enriched with nitrogen (N), phosphorus (P) and potassium (K). Sources of water pollution on farms include pesticides, slurry and farmyard manure, fertilizers, silage effluent, milk and other crop waste residues. A deteriorating environment puts man and other living components on the earth at risk. Therefore, periodic assessment of environmental media in the light of large scale agricultural activities is required to prevent their deterioration.

Environmental audit which is associated with a wide variety of activities in environmental protection and management (CSTI, 1994) is a veritable tool for such an assessment within the concept of Environmental management. It is a purposeful activity with the goal of maintaining and improving the state of an environmental resource affected by human activities (Barrow, 2005). It involves a systematic, documented, periodic and objective evaluation of how well organizations, their management and equipment are performing with the aim of safeguarding the environment by facilitating management control of environmental practices and assessing compliance with company policies, which would include meeting regulatory requirements (ICC, 1989; Sheate and Diaz-Chavez, 2014). Environmental auditing is a necessary part of environmental management playing a significant part in providing feedback mechanisms about overall environmental performance, and specific problem areas as well as corrective actions (Ding and Pigram, 1995), while incorporating it within management systems have reportedly induced more care about the environment (Sinclair-Desgagne and Gabel, 1997)

However, Enofe et al. (2013) affirmed that the more environmental audit is carried out, the less the effect on sustainable development, emphasizing that only few engage environmental audit services which might be a fall out from its voluntary nature. It is therefore necessary to incorporate environmental audit as part of research tools to independently asses the various activities, processes, and environmental performance of industries to ensure that their practices are ecologically sustainable.

This research assessed an integrated farm settlement's operational activities against specified environmental standards to establish a level of conformity or deviation from such standards and also determine the possible extent of damage to the environment resulting from these activities. The broad objective was to evaluate the environmental performance of the various farm units and their processs. Specific objectives were to determine some physical and chemical parameters of soil and water resources, ascertain the degree of compliance with certain environmental regulations and standards, assess current environmental management system and practices in operation and formulate suitable farm environmental policies.

2. METHODOLOGY

The study area is located in the South-western part of Nigeria between latitude 7°30′00″N to 7°12′00″N and Longitude 3°15′00″E to 3°45′00″E. The Integrated Farm studied is under the administration of the Directorate of University Farms (DUFARMS) within the Landscape of the Federal University of Agriculture, Abeokuta which is approximately 10,000 hectares.

It operates commercial operations of both Livestock and Crop Production aimed towards the provision of the necessary platform to impact needed practical skill for the realization of the University's objective to promote agricultural education and services for agricultural development. The Directorate comprises of the following Units:

Crops, Livestock, Cashew nut processing, Aquaculture, Palm Oil, Honey and Palm-wine production and occupies a landscape of approximately 150 hectares.

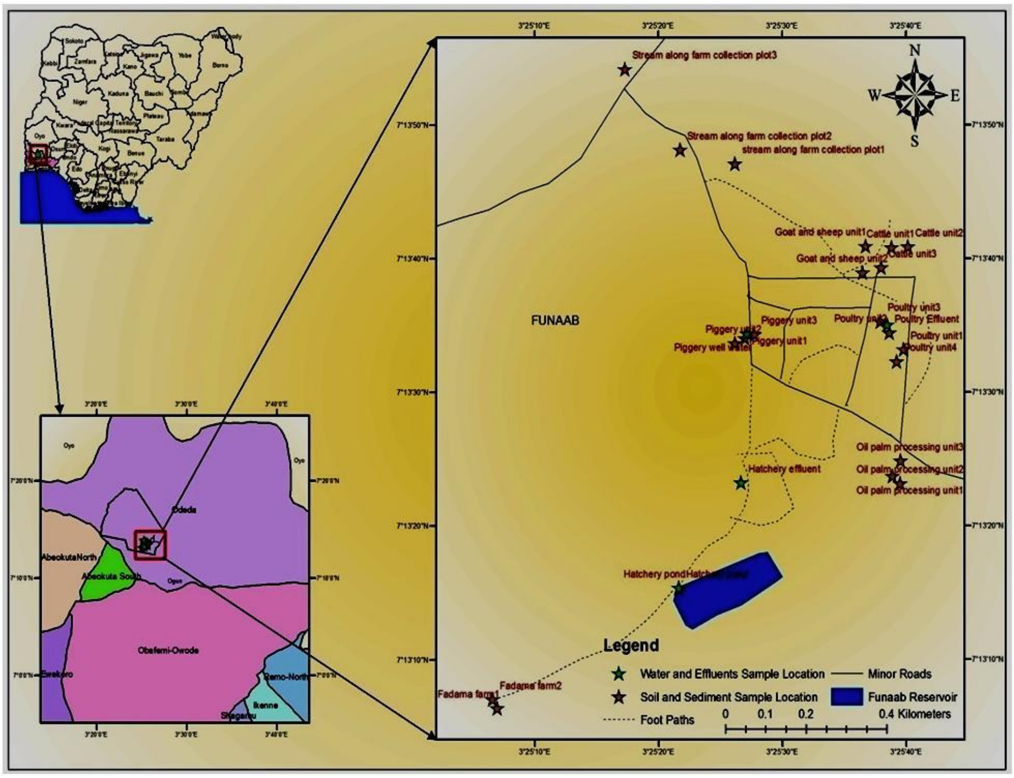

Figure 1. Map of study area showing the sampling locations

Table 1. Description of sample locations and their coordinates

S/N	Sample Code	Location	Latitude	Longitude
1	O1	Soil Within oil palm processing unit I	N7°13'395"	E3^{0}25'648"
2	O2	Soil Within oil palm processing unit II	N7^{0}13'386"	E3^{0}25'658"
3	O3	Soil Around oil palm processing unit I	N7^{0}13'414"	E3^{0}25'659"
4	P1	Soil Within poultry unit I	N7^{0}13'553"	E3^{0}25'663"
5	P2	Soil Within poultry unit II	N7^{0}13'574"	E3^{0}25'644"
6	P3	Soil Around poultry unit I	N7^{0}13'588"	E3^{0}25'632"
7	P4	Soil Around poultry unit II	N7^{0}13'538"	E3^{0}25'654"
8	C1	Soil Within cattle unit I	N7^{0}13'68"	E3^{0}25'647"
9	C2	Soil Within cattle unit II	N7^{0}13'681"	E3^{0}25'669"
10	C3	Soil Around cattle unit I	N7^{0}13'655"	E3^{0}25'633"
11	G1	Soil Within goat and sheep unit	N7^{0}13'682"	E3^{0}25'612"
12	G2	Soil Within goat and sheep unit	N7^{0}13'649"	E3^{0}25'608"
13	E1	Soil Within piggery unit I	N7^{0}13'567"	E3^{0}25'449"
14	E2	Soil Within piggery unit II	N7^{0}13'561"	E3^{0}25'436"
15	E3	Soil Around piggery unit I	N7^{0}13'572"	E3^{0}25'462"
16	S1	Sediment 1 from the stream along farm collection plot	N7^{0}13'785"	E3^{0}25'436"
17	S2	Sediment 2 from the stream along farm collection plot	N7^{0}13'802"	E3^{0}25'362"
18	S3	Sediment 3 from the stream along farm collection plot	N7^{0}13'903"	E3^{0}25'288"
19	S4	Sediment sample I from Fadama farm	N7^{0}14'106"	E3^{0}26'115"

Table 1. Description of sample locations and their coordinate (cont.)

S/N	Sample Code	Location	Latitude	Longitude
20	S5	Sediment sample II from Fadama farm	N7^{0}14'117"	E3^{0}26'109"
21	S6	Sediment sample from hatchery pond	N7^{0}13'256"	E3^{0}25'36"
22	HE	Hatchery effluent	N7^{0}13'387"	E3025'444"
23	PE	Poultry effluent	N7^{0}13'584"	E3^{0}25'641"
24	PW	Water sample from Piggery well	N7^{0}13'573"	E3025'452"
25	RP	Water sample from hatchery pond	N7^{0}13'256"	E3^{0}25'36"

The study focused on the analysis of the water, soil and sediment samples collected from the crop section plot, various units of the livestock section, hatchery reservoir, and the processing unit. A total of 15 soil samples, 6 sediments, 2 effluents and 2 water samples were collected across the various sections of the farm.

Soil sampling was done within and around specific points of farm operation with a soil auger at a maximum depth of 15 cm (top soil) while water samples were collected into sampling bottles from selected point sources. Sediment samples were taken with a core sampler. The coordinates of each sampling points were taken using a GPS device.

From Table 1, soil samples (S/N 1-15) were taken from various units of the farm settlements where farm activities are concentrated (within) and a few metres away from the activities (around). This was done so as to assess the disparity between the levels of impacts of the farm's activities on its immediate and surrounding environment. Samples (S/N 16-21) were sediment while samples (S/N 22-23) were taken from the animal processing effluent reservoir. Samples (S/N 24-25) were water samples. pH, temperature, total dissolved solid, electrical conductivity were determined using a portable probe (Hanna HI98129). Nitrate, phosphate, and available phosphorous were determined using a UV-Spectrophotometer at 210 nm. Total nitrogen was determined using the Macro-Kjeldahl method. BOD was determined using Winkler's method while COD was determined by titration method using ferrous ammonium sulphate. Sampling was repeated three times between April and October 2016 which is the end of dry season to the beginning of rainy season in order to capture the major planting season during which farm activities are at peak. Results of water samples were compared with World health Organisation (WHO, 2011) standard which is a standard for drinking water quality. This is because the sampled water sources are being utilised for drinking by local communities. Also, results of effluent discharges were compared with the limit for discharging into aquatic environment from the National Environmental Standards Regulations Agency (NESREA, 2009) National Environmental Regulations standards.

Using a purposive sampling method, six audit questionnaire were administered at each of the eight (Admin, Crops, Livestock, Cashew nut processing, Aquaculture, Palm Oil, Honey and Palm-wine production) farm units. The questionnaire had three sections. Section A was designed to gather general information on the unit while B focused on administrative features such as size, years of operation, environmental policy and procedures, workforce etc. Section C focused on farm activities, pollution sources and resource usage.

3. RESULTS AND DISCUSSION

The results of pH, temperature and electrical conductivity in soil were 7.67-10.20, 26.5-28.1 ºC, and 59-450 µS/cm respectively. pH results C1 (9.86±0.01), O2 (10.20±0.06) and O3 (9.18±0.01) revealed a relatively high alkaline condition which might have been created or exacerbated by long years of farming activities. Oil palm processing residues are disposed around sampling location O2 might have also contributed to high pH. Soil pH characteristics influences the surrounding water body, therefore a water source located close to a soil with high pH value might possess similar characteristics. Table 2 showed TDS values ranged between 29 and 243 mg/L. TDS and EC values in samples C1 and C2 (soil samples taken within cattle unit) were much higher compared with sample C3 (soil sample taken further away from cattle unit) which relates directly to the activity at the location where samples C1 and C2 were collected involves rearing of cattle semi-intensively, with the cattle dung kept openly around the premises which is responsible for the higher value recorded in sample C1 and C2.

The physical and chemical parameters (pH, temperature, TDS, EC, total nitrogen and available phosphorus) of sediment samples collected across streams as shown in Table 3 revealed pH value ranged from 8.91- 9.27. TDS values ranged between 53 and 139 mg/L with the highest value (139±0.00) in sample S5 while EC value ranged from 106-277 µS/cm. Total nitrogen composition in samples S1, S2 and S3 have relatively higher values of 2.85±0.01%, 2.61±0.00%, and 2.57±0.00% respectively than sediment sample S4, S5 and S6 with 0.86±0.02, 0.89±0.00, and 0.32±0.00% respectively.

High level use of both organic and inorganic fertilizers to boost production on farm plots around stream sediment locations S1, S2 and S3 might have contributed significantly to the higher amount of nitrogen as against the minimal farming activity in location S4, S5 and S6. Particularly, Sample S6 (sediment sample collected from hatchery pond) has the least total nitrogen value of 0.32%, because there was no significant farming activities associated with the location which is responsible for the low value for total nitrogen. Pesticides in sediments reportedly have a stronger impact on benthic macro-invertebrate community (Rasmussen, 2012). High level of nitrogen in the stream sediment could lead to nutrient loading and consequent algal bloom which could deprive aquatic life of much needed dissolved oxygen. Available phosphorus ranged from 46.30-112.30 mg/kg, with the lowest value in sample S6 (46.30±0.10 mg/kg) and the highest value in sample S1 (112.30±0.06 mg/kg).

Table 4 shows the results from the analysis of water samples for nitrate, phosphate, BOD, COD, pH, temperature, TDS, and EC in samples PW and RP Nitrate concentration ranged between 1.19-1.28 mg/L which is within the WHO (10 mg/L) and NESREA (20 mg/L) limits while phosphate concentration values ranged from 0.10-0.12 mg/L which also falls within the NESREA (5 mg/L) limit. BOD and COD in water samples PW and RP were 0.50±0.01, 0.70±0.09 and 63±0.06, 32±0.15 respectively. The values were below the stipulated level by both standards. pH values of 9.10±0.06 and 9.06±0.04 were recorded for samples PW and RP respectively which was slightly above the levels stipulated by both standards. Meanwhile, TDS and EC values were found within stipulated levels having values of 90±2.00 and 177±1.00 for PW along with 252±0.58 and 509±2.00 for RP.

However, Tomer et al. (2010) reported a higher concentration of nitrogen between 12.7-34 mg/L with phosphorus level slightly above 1.0 mg/L from storm-water in crop and livestock production farm while Todd and Struger (2014) reported high herbicide concentrations of about 8.79 mg/L in urban streams. However, David and Lowell (2000) reported that bio-absorption and denitrification process in stream which could be responsible for the low values of nutrients in the study area dominated by agricultural non-point sources of nitrogen and phosphorus. However low, McFarland and Hauck (2000) stated that bioavailability of nutrient in receiving aquatic systems could increase their potential for accelerated eutrophication.

For effluent samples HE and PE, as presented in Table 4, pH values were slightly alkaline and above the guideline values of NESREA (6-9) standard. TDS and EC levels in HE was 318±1.73 ppm and 643±6.25 µS/cm respectively while PE had 404±15.10 ppm and 814±5.29 µS/cm. Sample HE had values of 1.374±0.00 ppm, 0.172±0.00 µS/cm, and 1.20±0.01% for Nitrate, Phosphate and BOD respectively while these parameters were not detectable (ND) for PE. COD level was 290±0.27 and 382±1.87 mg/L in samples HE and PE respectively. The COD values obtained in these samples were beyond the limits set by NESREA (80 mg/L). These locations were the poultry and fish hatchery units where effluents from fish and poultry animal processes/production are discharged into the drainage without treatment.

Audit results showed an indiscriminate disposal of residual material (sludge) at oil palm processing unit which could be responsible for the high soil pH, EC and TDS value recorded from samples taken around the oil processing area. At the poultry unit, there was also an indiscriminate discharge of poultry effluent onto the adjoining road which is likely to be carried by surface runoff into adjoining water bodies thereby reducing their quality. This indicates that the farm is not totally integrated as expected. There ought not to be any unutilized waste in a fully integrated system.

Table 2. Physical parameters of soil samples

S/N	Location	pH	TDS (ppm)	EC (μS/cm)	Total Nitrogen (%)
1	G1	7.67 ±0.01^{a}	74±0.00^{d}	144±1.00^{c}	1.82±0.55^{bc}
2	G2	8.94±0.01^{ij}	66±0.00^{c}	138±0.58^{c}	1.16±0.42^{c}
3	C1	9.86±0.01^{l}	147±1.16^{i}	295±0.00^{f}	2.34±0.45^{abc}
4	C2	8.51±0.01^{d}	120±1.53^{g}	238±0.00^{e}	2.33±0.96^{abc}
5	C3	8.99±0.01^{j}	58±0.00^{b}	117±0.00^{b}	2.73±1.31^{abc}
6	O1	8.41±0.02^{c}	99±0.58^{f}	197±1.16^{d}	3.08±1.13^{ab}
7	O2	10.20±0.06^{m}	243±0.00^{l}	450±26.46^{h}	1.54±0.31^{bc}
8	O3	9.18±0.01^{k}	95±1.00^{e}	202±1.00^{d}	2.67±0.92^{abc}
9	P1	7.98±0.01^{b}	145±1.00^{h}	289±0.00^{f}	2.33±0.74^{abc}
10	P2	9.00±0.10^{j}	97±0.58^{f}	194±1.00^{d}	1.21±0.58^{c}
11	P3	8.81±0.01^{fg}	59±1.00^{b}	120±1.00^{b}	2.48±0.83^{abc}
12	P4	8.90±0.10^{hi}	29±1.00^{a}	59±1.00^{a}	3.53±0.62^{a}
13	E1	8.86±0.01^{gh}	193±2.00^{k}	385±1.00^{g}	2.66±0.71^{abc}
14	E2	8.65±0.02^{e}	188±2.00^{j}	376±2.00^{g}	2.33±0.57^{abc}
15	E3	8.77±0.02^{f}	119±2.00^{g}	239±3.00^{e}	3.11±1.31^{ab}

Note: Values in the same column and with different superscript are significantly different at $p < 0.05$

Table 3. Physical and chemical parameters of sediment samples

S/N	Location	pH	TDS (ppm)	EC (μS/cm)	Total nitrogen (%)	Available Phosphorus (mg/kg)
1	S1	9.07±0.01^{b}	55±0.58^{d}	111±1.53^{e}	2.85±0.01^{a}	112.30±0.06^{a}
2	S2	9.21±0.02^{a}	114±0.00^{b}	230±0.58^{b}	2.61±0.00^{b}	100.40±0.23^{b}
3	S3	9.00±0.08^{c}	95±2.08^{c}	180±0.00^{c}	2.57±0.00^{c}	81.90±0.06^{c}
4	S4	9.20±0.01^{a}	56±0.58^{d}	113±1.16^{d}	0.86±0.02^{e}	62.70±0.06^{e}
5	S5	8.91±0.01^{d}	139±0.00^{a}	277±0.00^{a}	0.89±0.00^{d}	69.50±0.00^{d}
6	S6	9.27±0.00^{a}	53±1.00^{e}	106±0.00^{f}	0.32±0.00^{f}	46.30±0.10^{f}

Note: Values in the same column and with different superscript are significantly different at $p < 0.05$

Table 4. Concentration of chemical and biological parameters in effluent and water samples from the study area

S/N	Sample	Nitrate (mg/L)	Phosphate (mg/L)	BOD (mg/L)	COD (mg/L)	pH	TDS (ppm)	EC (μS/cm)
1	HE	1.374±0.00^{a}	0.172±0.00^{a}	1.20±0.01^{a}	290±0.27^{b}	9.63±0.03^{b}	318±1.73^{b}	643±6.25^{b}
2	PE	ND	ND	ND	382±1.87^{a}	9.82±0.02^{a}	404±15.10^{a}	814±5.29^{a}
3	PW	1.199±0.00^{b}	0.101±0.00^{c}	0.50±0.01^{c}	63±0.06^{c}	9.10±0.06^{c}	90±2.00^{d}	177±1.00^{d}
4	RP	1.288±0.00^{c}	0.122±0.00^{b}	0.70±0.09^{b}	32±0.15^{d}	9.06±0.04^{c}	252±0.58^{c}	509±2.00^{c}
NESREA (2009)		20	5	30	80	6-9	2000	NA
WHO (2011)		10	NA	10	NA	6.5-8.5	1500	1800

Note: Values in the same column and with different superscript are significantly different at $p < 0.05$

Fertilizer, pesticide and antibiotics were used in the crop and livestock production sections. Fertilizers commonly used in the crop production units include organic manure from the livestock sections, N.P.K and Urea with usage rating of 3/5. Animal wastes could release zoonotic pathogens into the environment and are now recognized as a public health concern (Dufour et al., 2012). Runoff from these areas could deliver these pathogenic microbes into the stream. Off farm contamination can potentially occur inadvertently, such as in uncontrolled releases by runoff or infiltration into soils and ground water (Sobsey et al., 2004).

Pesticide usage on the crop collection plot was high (usage rating of 4 out of 5), while the common pesticides used include Larraforce and Gypermethrine. Stimulation and inhibition of soil microorganisms could be caused by repeated use of pesticides (FAO and IAEA, 1999) while they potentially impact the macroinvertebrate community (Rasmussen, 2012). The use of drugs and antibiotics such as Anti-helmith was peculiar with the livestock sections (cattle unit) and other forms of multivitamins. The drugs were administered by trained personnel who ensure proper application and sanitary disposal. 60% of farm area was affected by soil erosion.

Water usage was about 1,000 Litres per day; meanwhile there was no strategy to check water wastage from a leaking pipe or tank as observed in the oil palm processing unit. Solid wastes including carcasses were burned in open dumpsites on the farm settlement which were not well marked-out, demarcated or fenced. This could lead to pollution of air surrounding water bodies. The farm environmental plan put in place include the restriction of dumping of dung around the pen, general sanitation of the farm, burning and burying of carcasses. Also, there is a recommended distance stipulated between different livestock houses while crop activities are also separated from livestock activities.

Notably, the environmental management controls in place were inadequate to safeguard the surrounding environment from the potential impact of large scale farming activities.

4. CONCLUSIONS

In order to ensure a sustainable integrated farm, a better approach aimed at zero wastage should be adopted. Since the farm has both livestock and crop sections, the livestock unit should be fed with selected crops residues which can be re-processed to meet the nutritional requirement of the livestock while the use of organic manure from animal dropping (from livestock section) should be encouraged rather than the excessive use of inorganic fertilizers known for soil nutrient depletion and water source pollution.

Chemical control of pest and weed should be reduced to the minimal while cultural and physical approach should be encouraged due to its minimal negative environmental impact. In view of high volume of daily water extraction, steps should be taken to avoid water resource wastage because freshwater is a common resource that should be conserved.

All effluents to be discharged should be treated to meet the required discharge standard while undesirable high pH levels can be minimized by mildly increasing the acidity of the soil so as to bring the pH level to the standard limit.

A detailed farm environmental plan (FEP) which incorporates the above information should be developed and implemented as an environmental guide for all farm activities while the farm should set up an environmental monitoring unit that will be responsible for the regular assessment of the environmental media on the farm and immediate environment as a form of self-check so the farm can assess their own level of compliance with their environmental plan and existing standards, hence revealing their level of environmental performance.

ACKNOWLEDGEMENTS

We appreciate all members and staff of DUFARMS limited for their immense contributions and cooperation with the research team.

REFERENCES

Antonio R, Silva S. Integrated crop-livestock farming systems, Livestock Thematic Papers; Tools for Project Design. International Fund for Agricultural Development [Internet] 2010. [cited 2015 August 12]. Available from: https:// www.ifad.org/ documents/ 10180/31bb4140-1a73-4507-83ed-6fc8cb64bed7

Barrow CJ. Environmental Management and Development. London and New York: Routledge; 2005.

Council of Science and Technology Institutes (CSTI). CSTI Environmental Information Paper 2. London: CSTI Advisory Committee on the Environment; 1994.

David MB, Lowell EG. Anthropogenic input of nitrogen and phosphorus and riverine export for Illinois, USA. Journal of Environmental Quality 2000;29(2):494-508.

Delgado C, Rosegrant M, Henning S, Ehui S, Courbois C. Livestock to 2020: The Next Food Revolution. Food, Agriculture and the Environment Discussion Paper 28, Washington, D.C: International Food Policy Research Institute; 2001. p. 1-83.

Ding P, Pigram J. Environmental audits: emerging concepts in sustainable tourism development. The Journal of Tourism Studies 1995;6(2):1-10.

Doom RJM, Natschke DF, Meeuwissen CP. Review of emissions factors and methodologies to estimate ammonia from animal waste handling. U.S. Environmental Protection Agency: National Risk Management Research Laboratory; [Internet] 2002.

[cited 2015 August 5]. Available from: https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryID=55098

Dufour A, Bartram J, Bos R, Gannon V. Animal Waste, Water Quality and Human Health. London, UK: WHO, IWA Publishing; 2012. p. 489-510.

Enofe A, Mgbame C, Obazee U, Edeoghon O. Environmental auditing and sustainable development in Nigeria. Research Journal of Finance and Accounting 2013;4(11):91-7.

Food and Agriculture Organization of the United Nations (FAO), International Atomic Energy Agency (IAEA). Impact of long term pesticide usage on soil properties using radiotracer techniques. Proceedings of a Final Research Coordination meeting organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture; 1999 May 24-28; Hangzhou, Zhejiang; China; 2014.

Hoff SJ, Hornbuckle KC, Thorne PS, Bundy DS, O'Shaughnessy PT. Emissions and Community Exposures from CAFOs. In: Iowa Concentrated Animal Feeding Operations Air Quality Study. ISU/UI Study Group: University of Iowa College of Public Health, Iowa City, IA: 2002. p. 45-85.

International Chamber of Commerce (ICC). Environmental Auditing. Paris: ICC Publishing; 1989.

McFarland AMS, Hauck LM. Relating agricultural land uses to in-stream stormwater quality. Journal of Environmental Quality 2000;28(3)836-44.

National Environmental Standards Regulations Agency (NESREA). Federal Republic of Nigeria Official Gazette: National Environmental Regulations: 2009. p. 1299-389.

Rasmussen JJ. Pesticide Effects on the Structure and Function of Stream Ecosystems [dissertation]. Department of Bioscience, AARHUS University; 2012.

Sheate W, Diaz-Chavez RA. Centre for development, environment and policy: module introduction; environmental auditing and environmental management systems [Internet] 2014. [cited 2015 August 8]. Available from: https://www.soas.ac.uk/cedep/programmes/modules/file68625.pdf

Sigurdarson ST, Kline JN. School proximity to concentrated animal feeding operations and prevalence of asthma in students. Cardio-pulmonary and Critical Care Journal 2006;129:1486-91.

Sinclair-Desgagne B, Gabel LH. Environmental auditing in management systems and public policy. Journal of Environmental Economics and management 1997;33(3):331-46.

Sobsey MD, Khatib LA, Hill VR, Alocilja E, Pillai S. Pathogens in animal wastes and the impacts of waste management practices on their survival, transport and fate. Animal Agriculture and the Environment 2004;609-66.

Todd BA, Struger J. Changes in acid herbicide concentrations in urban streams after a cosmetic pesticides. Challenges 2014;5:138-51.

Tomer MD, Wilson CG, Moorman TB, Cole KJ, Heer D, Isenhart TM. Source-pathway separation of multiple contaminants during a rainfall-runoff event in an artificially drained agricultural watershed. Journal of Environmental Quality 2010;39(3):882-95.

Unites States Environmental Protection Agency (USEPA). Inventory of U.S greenhouse gas emissions and sinks: 1990-2014 [Internet]. 2015. [cited 2015 August 5]. Available from: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

VanKeulen H, Schiere H. Crop-livestock systems: old wine in new bottles? in new directions for a diverse planet. Proceedings of the 4th International Crop Science Congress; 2004 Sep 26-1 Oct; Brisbane: Australia; 2004.

World Health Organization (WHO). Guidelines for Drinking Water Quality. 4th ed. 2011. p. 564.