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Research Paper

Quantification of Plankton and Benthic Macro-invertebrates in a Simulated Chicken Manure and Pig Dung Fertilized Mesocosms

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A simulated study of chicken manure and pig dung fertilized mesocosm was carried out in wet and dry season on the fish farm of Federal College of Education (FCE), Pankshin, Plateau State, Nigeria. The experiments were conducted using ten kilograms of benthic soil from an unstock earthen pond that was carefully lifted, weighed and transferred into sixteen different plastic mesocosms (capacity 40 litres each). A total of three (3) test concentrations; 120, 80 and 40 g each for chicken manure and pig dung and one (1) control (0 g) each duplicate replicated were labelled A_1cm, A_2cm, B_1cm, B_2cm, C_1cm, C_2cm and A_1pd, A_2pd, B_1pd, B_2pd, C_1pd and C_2pd while D_1 and D_2 served as controls. Each plastic mesocosm was stirred weekly and samples taken to the laboratory for plankton analysis while the benthic soil was scooped weekly for benthic macro-invertebrates identification and counting. The result showed that the species composition of plankton comprises Diatom sp. (65%), Daphnia sp. (4%), Cyclope sp. (3%), Rotifer sp. (5%), Volvox sp. (9%), Euglena sp. (2%), Spirogyra sp. (3%), Amoeba sp. (1%), Nostoc sp. (2%), Paramecium sp. (2%), Synedra sp. (.1%) Butoyoccocus sp. (1%), Limnocalamus sp. (1%), Phacus sp. (.%), Cymbella sp. (2%), Triponema sp. (1%), Tuberlaria sp. (1%), Closterium sp. (.3%) and Chlamydomonas sp. (2%). Macro invertebrates comprised of Chironomussp (66%), Water bug (2%), Dragonfly larvae (1%), Water cricket (3%) and Mosquito larvae (33%). The effect between chicken manure and pig dung on plankton and macro-invertebrates was significantly high (P>0.05) and the effect between the different concentrations; 120, 80, 40 g of chicken manure and pig dung on plankton and macro- invertebrates was significantly less (P<0.05). It was concluded that 80 g/L of chicken manure and 80 g/L of pig dung comprised more organisms among the treated mesocosms and therefore recommended for use.

Keywords: Plankton, Macro-invertebrates, chicken manure and pig dung

INTRODUCTION

Pond fertilization practices using animal wastes are widely used in many countries to sustain productivity at low cost (Majumdar *et al*., 2002). Studies on the fertilizing efficiency of chicken manure in fish ponds, either alone or in combination with other animal manure were conducted by Wade and Absalom, (2010); Orji and Agunwa, (2005; Ekelemu and Nwabueze, (2011). Cow dung, poultry droppings and pig dung can be successfully used to fertilize fish ponds in fish culture as they are capable of supplying the desired nutrients required for plankton production (Orji and Agunwa, 2005; Ekelemu and Nwabueze,2011). Adewumi *et al.* (2011); Orihabor and Ansa, (2006) in separate studies of organic manure observed that nitrogenous wastes from farm yard manure efficiently influence the pond water productivity as it supplies the plankton with essential nutrients needed for multiplication and growth which in turn serve as life food organisms for fish and fish-food organisms. Plankton are all plants and animals that drift within the ocean currents as inhabitants of the open waters of the sea and fresh waters Harmer, (2003). Harmer, (2003) further observed that zooplankton, the planktonic animals, are all weak swimmers, whereas phytoplankton, planktonic plants do not swim at all. Plankton provides humans with numerous benefits, in view of the fact that they are located near the bottom of the food chain in nature, just above bacteria. Thus, they serve a crucial role in sustaining the higher eukaryotes in fresh and marine waters in addition to directly and indirectly supplying organic molecules (such as sugars) for other organisms (Steven, 2005).

Benthic macro-invertebrates are small animals living among the sediments and stones on the bottom of streams, rivers and lakes (Wallace and Webster, 2013). According to Merritt *et al.* (2008), benthic macro-invertebrates are small living organisms that can be seen by the naked eyes (without the aid of a microscope), which live on or in the bottom of water bodies. According to (Merritt *et al.*,2008) insects comprise the largest diversity of these organisms and include May flies, Stones flies, Caddis flies, Beetles, Midges, Crane flies, Dragonflies among others. On the other hand, Voshel, (2002) reported that other members of the benthic macro-invertebrates community are Snails, Clams, Aquatic Worms and Crayfish. Benthic macro-invertebrates are very important in the food Chain of aquatic environment as they are important players in the processing and recycling of nutrients and are major food sources for fish and other aquatic animals (Wallace and Webster, 2013). They play a significant role in nutrient cycles, primary productivity, decomposition and translocation of materials and constitute an important source of food for numerous species of fishes (Thais and Elvio, 2013).

In fish farming, nutrition is critical because feed represent 40-50% of the production cost (Steven, 2009). According to Steven, (2009) supplemental diets are intended only to support the natural food (insects, algae, and small fish) normally available to fish in ponds or outdoor raceways. Food and Agricultural Organization FAO,(2013) opined that fish need to feed on organic materials such as plants, other animals, or prepared feeds containing plant and or animal materials. It further observed that natural foods of fish are found in the pond, which may include detritus, bacteria, worms, insects, snails, aquatic plants and fish. The recycling of nutrients is critical for the sustenance of ecosystem (Thais and Elvio, 2013). And this involves natural recycling as the transformation of nutrients from one chemical form to another and or the flux of nutrients between organism, habitats, or ecosystems. According to FAO, (2013) Nutrient inputs from outside ecosystem boundaries, often referred to as allochthonous inputs are also important in many ecosystems. The use of animal material (waste/droppings) to modify the population of plankton and benthic macro invertebrates as natural food source is key to fish production (Sasmal *et al.,*2010; Dhawan and Kaur, 2002; Michael, 2002). This study was designed to test the effect of chicken and pig dung manure on the composition and abundance of plankton and benthic macro invertebrates which will serve as natural and cheap source of food for fish other than the artificial food source that are beyond the reach of most farmers.

MATERIALS AND METHODS

The experiments were conducted in sixteen (16) outdoor plastic mesocosms (capacity 40 litres each) of dimension (42 x 30 x 25) cm. A total of three (3) test concentrations; 120, 80 and 40 g each for chicken manure and pig dung and one (1) control (0 g) each duplicate replicated were labelled A_1cm, A_2cm, B_1cm, B_2cm, C_1cm, C_2cm and A_1pd, A_2pd, B_1pd, B_2pd, C_1pd and C_2pd with 120 g, 80 g and 40 g respectively while D_1 and D_2 served as controls and manure was added to these plastic mesocosms. Benthic soil was collected from the earthen pond site, while animal droppings were collected from poultry and piggery units of the Department of Agricultural Science of the Federal College of Education, Pankshin, Plateau State, Nigeria. Chicken manure and pig dung were collected, dried, crushed and sieved using 3 mm mesh size sieve. Proximate analysis of the samples (chicken manure and pig dung) were carried out before weighing into 120, 80 and 40 g respectively and subsequently into separate mesocosms on the 20th August, 2014. The pond contained water hence a (30 x 17) cm metal blade spade with 2 m handle was used to scooped 15 cm depth into the benthic soil. The plastic mesocosms were first weighed to determine the initial weight before transferring the benthic soil gradually into it until 10 kg was reached for each of the 16 plastic mesocosms. The required chicken manure and pig dung concentrations; 120, 80 and 40 g were then applied dried into each mesocosms and subsequently stirred to enable uniform mixture with the benthic soil before 20 litres of water was added equally into each mesocosms. The mesocosms were finally randomized on a platform (1m above ground).The experiment lasted for eleven weeks. Water samples from each mesocosms were collected weekly at 9:00 am by stirring and sieving into 50 ml plastic specimens bottles. Collected samples were taken to the laboratory and centrifuged for 5 min to desiccate the supernatant after which 1 ml sub-samples were pipette into a counting chamber (McMaster Slide G2A) and viewed through a compound microscope for identification, quantification and estimation of plankton fraction in each sample. Plankton samples collected were identified to species level using microscope at a magnification of x100 and keys according to Phyllis *et al.* (1997); Ademola, (1998) and Gupta and Gupta, (2006). Determination of macro-invertebrates was carried out by scooping the benthic soil with a hand trowel. The scooped benthic soil was then transferred into an aluminum tray for identification and counting. Hand lens were used for identification of organisms that are too tiny to be seen. Identification was done according to the method described by: Phyllis *et al.* (1997), Ademola, (1998), Gupta and Gupta, (2006). Relative abundance and species richness were calculated using Shannon–Wiener's diversity index (Shannon, 1948) and Evenness or Equitability index (Pielou, 1966):

$H' = \sum PilnPi$ Shannon, (1948)

$J = \frac{H'}{lns}$

Pielou, (1966)

Where:
S= the number of species
P = proportion of individuals of the species
Ln = log base n

Microbial number was calculated according to the formula by Boyd and Lachktoppler, (1979):

$$\text{Number of zooplankton/ml} = \frac{T \times 1000}{A \times N \times \text{Vol of Plastic in ml/vol of Sample}}$$

T =total number of zooplankton counted
A =area of grid in mm^2
N = number of grid counted
1000 = area of counting chamber in mm^2.

RESULTS

The results of the mean value (±) of the environmental parameters of water in the mesocosms treated with chicken manure and pig dung, and the control mesocosms for the period of the experiment remained within the favourable range required for plankton and macro-invertebrate growth (Table 1).

Plankton and benthic macro invertebrates' abundance and distribution in mesocosms treated with chicken manure and pig dung over eleven weeks

Results obtained during the study on the quantification of plankton and benthic macro -invertebrates in a simulated chicken manure and pig dung fertilized mesocosms showed various patterns of growth. The results indicated changes in species composition, abundance and diversity. The results of various plankton and macro-invertebrate species and composition are represented in (Figures 1 and 2) respectively. A total of nineteen (19) species of plankton were identified in the study (Figure1) and five (5) macro-invertebrate species were identified (Figure 2). The total percentage abundance of plankton species observed in all the treatment and control mesocosms during the eleven weeks study ranged from 0.1 to 65% with *Diatom sp.* having the highest while, *Phacus sp.* was the least. The percentage species composition of plankton comprises *Diatom sp. (65%), Daphnia sp. (4%), Cyclope sp. (3%), Rotifer sp. (5%), Volvox sp. (9%), Euglena sp. (2%), Spirogyra sp. (3%), Amoeba sp. (1%), Nostoc sp. (2%), Paramecium sp. (2%), Synedra sp. (1%), Butoyoccocus sp. (1%), Limnocalamus sp. (1%), Phacus sp. (1%), Cymbella sp. (2%), Triponema sp. (1%), Tuberlaria sp. (1%), Closterium sp. (3%) and Chlamydomonas sp. (2%)* (Figure 1).The overall percentage abundance of macro-invertebrates observed in all the treated mesocosms and the control during the period of the study ranged from 0.1 to 66% with *Chironomus sp.* having the highest and dragonfly larvae the least (Figure 2). Macro invertebrates comprised of *Chironomussp (66%), Water bug (.2%), Dragonfly larvae (1%), Water cricket (.3%) and Mosquito larvae (33%)*.

Community structure of plankton and benthic macro-invertebrares in chicken manure and Pig dung treated mesocosms.

The values of Shannon diversity index and species evenness index varied considerably among treated mesocosms and control. The values of Shannon diversity index and species evenness index were significantly higher (*P<0.05*) for plankton than macro-invertebrates. The examination of plankton and macro-invertebrate showed that species diversity and richness differed considerably between the manure treated mesocosms and control (Figures 3-6). The Shannon diversity index distribution of plankton in treated chicken manure mesocosms ranged from 2.4 to 3 (H) while the pig dung treated mesocosms ranged from 1.6 to 2.7 (H) (Figure 3). The Shannon diversity index distribution of macro-invertebrates in chicken manure and pig dung treated mesocosms ranged from 0.3 to 1 and 0.1 to 0.4 (H) respectively (Figure 4).The species evenness index distribution of plankton in chicken manure and pig dung treated mesocosms ranged from 0.3 to 0.9 and 0.1 to 0.4 (H) respectively (Figure 5). On the other hand, the species evenness index distribution of macro-invertebrates in chicken manure and pig dung treated mesocosms ranged from 0.3 to 0.7 and 0.2 to 0.5(H) (Figure 6). Diatom which formed substantial proportions of the total plankton composition in the manure treatments were not significant (P>0.05) in the control mesocosms. Other plankton represented in the control mesocosms were not significant (P>0.05) compared to manure treated mesocosms. Within the different concentrations of the two manure (chicken and pig) treatments, the abundance, composition and diversity of species varied considerably. The difference between treatments were significantly high (P<0.05) however, abundance and diversity of plankton and macro-invertebrate was significantly higher (P<0.05) than control (Figures 3-6).

DISCUSSION

The results of the composition, abundance, species richness, diversity and evenness indices of plankton and

Table 1. Mean Values of Water Quality Parameters of Plastic Mesocosms with Different Levels of Chicken and Pig Dung.

Parameter	Poultry Droppings Conc.(g/L)				Pig Dung Conc.(g/L)			
	120	80	40	0	120	80	40	0
TEMP (°C)	21.19±0.005	21.16±0.005	21.10±0.005	21.85±0.05	19.97±0.005	19.79±0.015	19.38±0.05	21.5±0.4
FCO_2	0.135±0.005	0.12±0	0.085±0.005	0.055±0.005	0.125±0.005	0.105±0.005	0.075±0.005	0.045±0.005
pH (mg/L)	9.77±0.04	8.505±0.005	7.54±0.065	7.3±0	8.87±0.04	8.42±0.005	7.57±0.75	7.45±0.05
PO_4 (mg/L)	0.07±0	0.06±0	0.05±0	0.04±0	0.06±0	0.05±0	0.03±0	0.03±0
NO_3 (mg/L	8.35±0.35	8.5±1.5	7.25±0.25	6.25±0.25	7.65±0.15	9.5±0.5	5.9±0.1	6.25±0.25
NH_3 (mg/L)	0.065±0.005	0.07±0	0.625±0.025	0.75±0.05	0.575±0.025	0.6±0	0.5±0	0.75±0.05
NO_2 (mg/L)	0.045±0.005	0.055±0.005	0.04±0	0.03±0	0,055±0.005	0.045±0.005	0.04±0	0.03±0

DO= Dissolved Oxygen
FCO_2 = Free Carbon dioxide
pH= Hydrogen ion concentration
Temp= Temperature
PO_4= Phosphate
NO_3= Nitrate
NH_3= Ammonia
NO_2= Nitrite

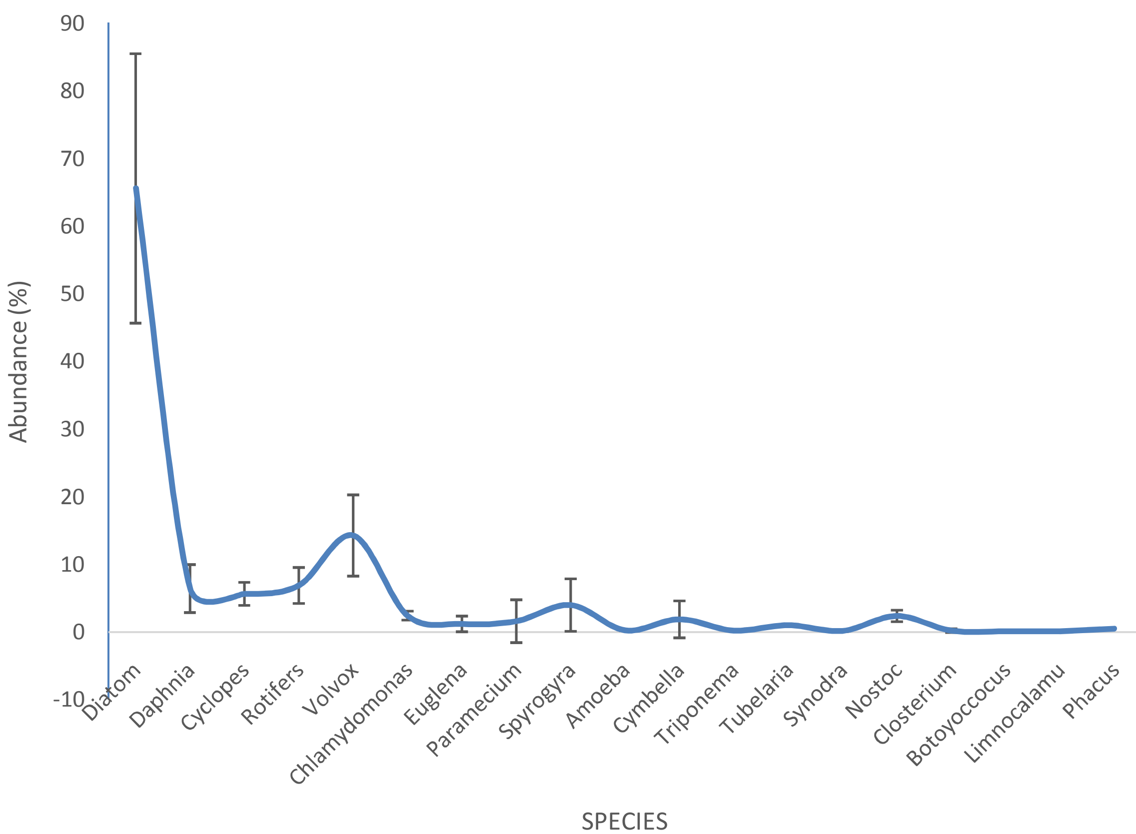

Figure 1. Abundance of Plankton species in mesocosms treated with chicken manure and Pig dung over eleven weeks.

macro-invertebrates found in chicken manure and Pig dung treatment and control mesocosms varied. The plankton and macro-invertebrates richness of the studied mesocosms revealed some interesting findings. A total of nineteen micro-invertebrate species were recorded and the sustainable increase in species composition and

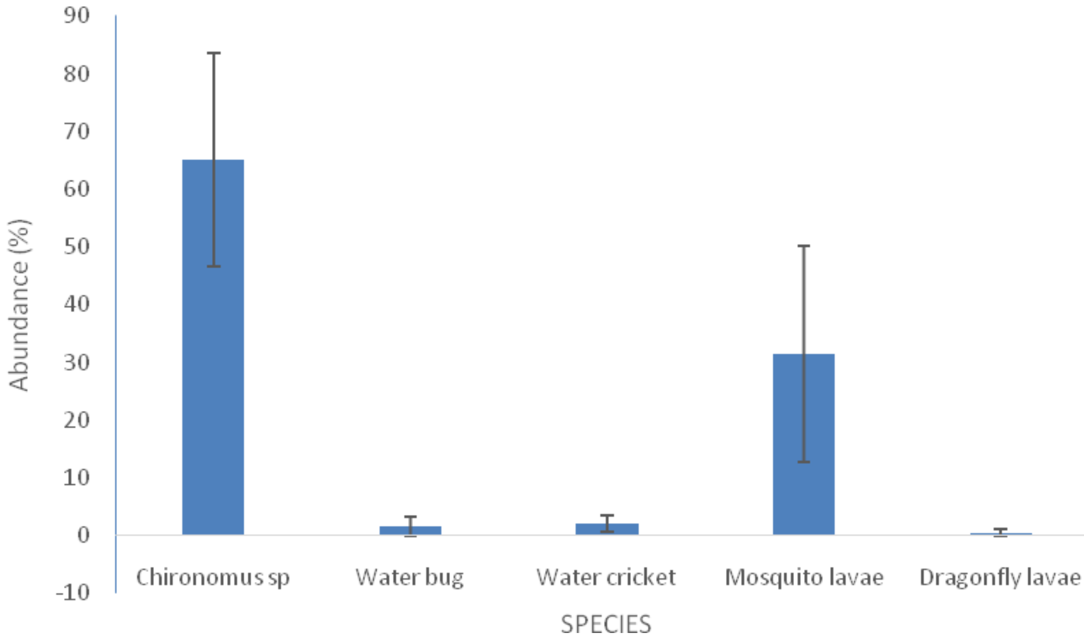

Figure 2. Abundance of Benthic Macro-invertebrate Species in mesocosms treated chicken Manure and Pig Dung over Eleven Weeks.

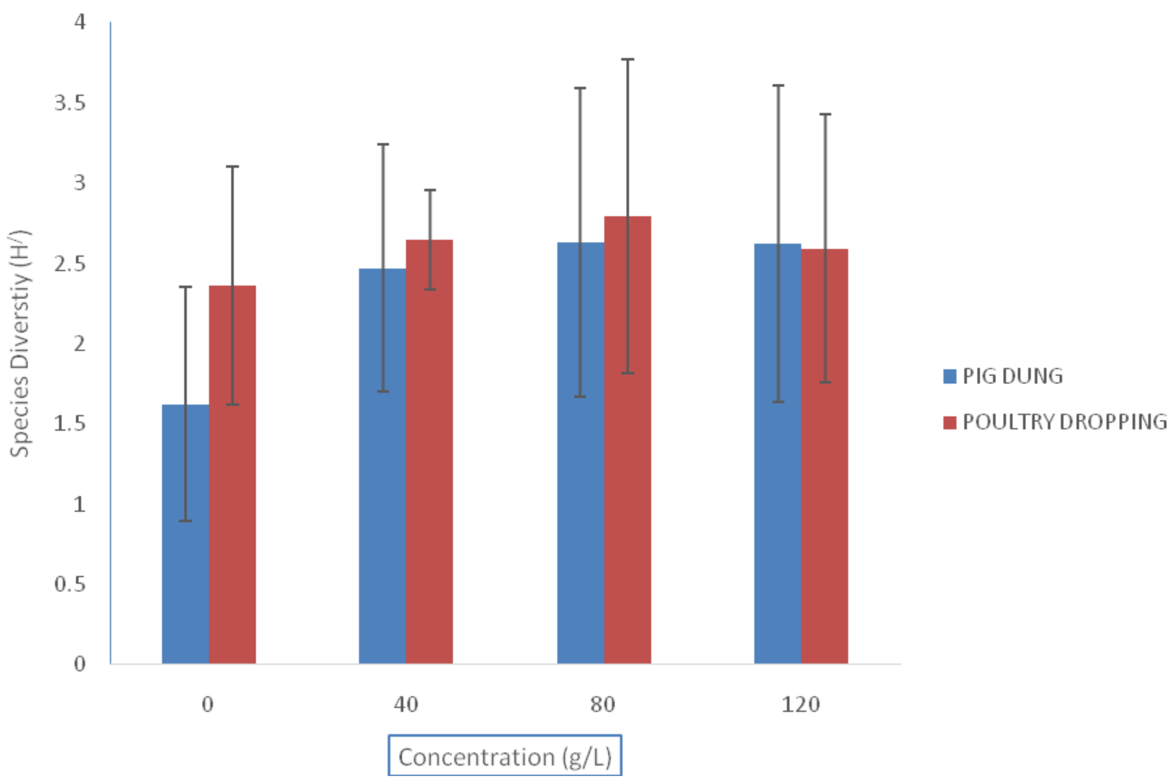

Figure 3. Shannon diversity index of weekly abundance and distribution of plankton in chicken manure and pig dung mesocosms.

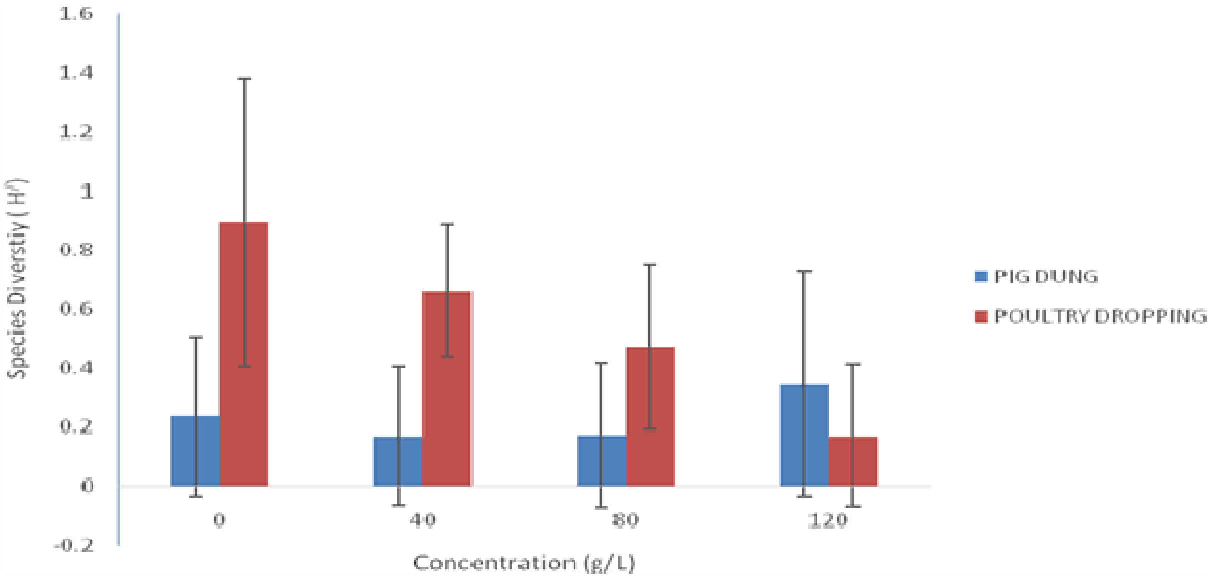

Figure 4. Shannon diversity index of weekly abundance and distribution of Benthic Macro invertebrates in chicken manure and pig dung treated mesocosms.

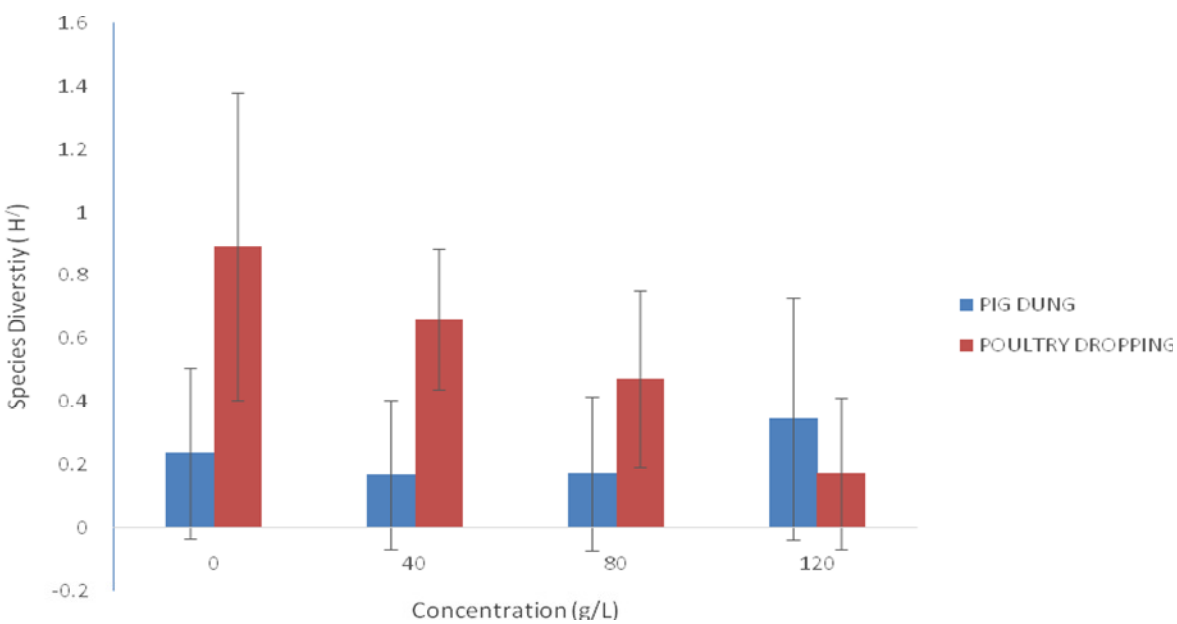

Figure 5. Species evenness index abundance and distribution of plankton in chicken manure and pig dung treated mesocosms.

abundance in mesocosms treated with manure may be traced to differential quantity and quality of nutrients in poultry and pig manure. This is in agreement with Wade and Absalom, (2010), who reported that changes in time in the application of chicken manure are determinant of the differences in water quality, species composition and diversity. The authors further observed that manure levels encouraged heterotrophic development hence their (heterotrophs) response was greater in number in ponds with higher levels of chicken manure. The richness indices varied differently with number of species and individuals in this work is in line with that of Yap *et al.*

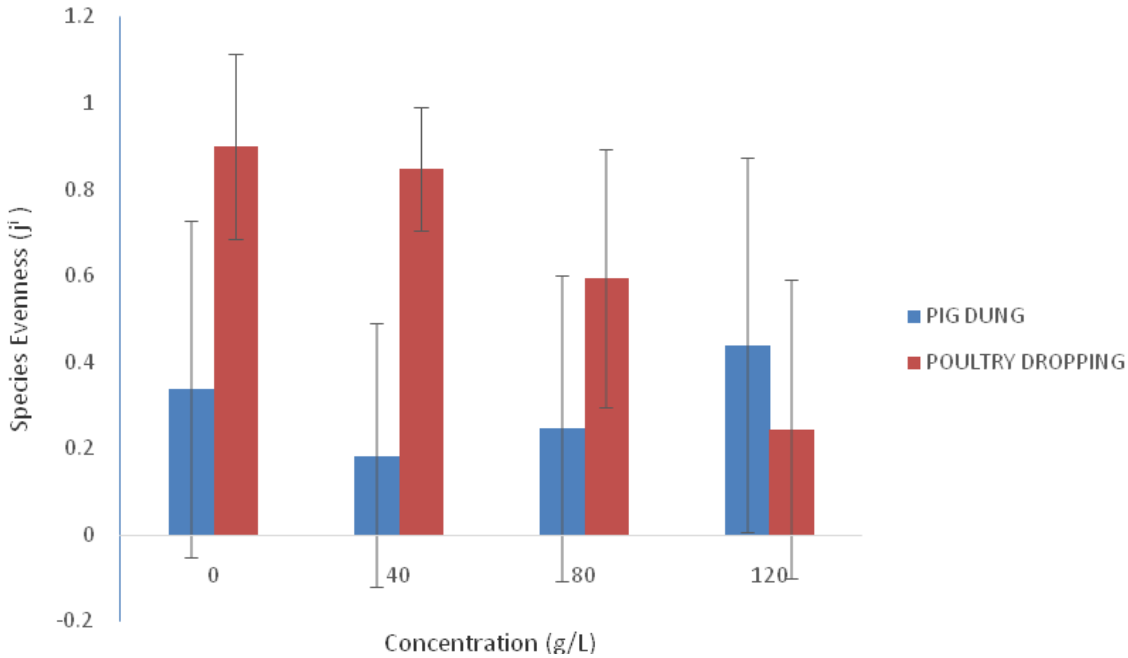

Figure 6. Species evenness index abundance and distribution of benthic macro invertebrates in chicken manure and pig dung treated mesocosms.

(2003); Isabel *et al.* (2005), Lakhi, (2013) and Alison *et al.* (2008) reported that Shannon index value (H^1) far below 3 is not at all satisfactory while H^1 value above 3 indicates better balance and stable habitat condition. In this study, higher micro plankton diversity was recorded in the chicken manure higher than Pig dung treated mesocosms i.e 1.132-4.218 and 0.491-4.155 for chicken manure and pig dung treated mesocosms respectively. The result indicates that the Shannon diversity of the treated mesocosms though not high, was significantly higher in 80 g/L of poultry droppings and pig dung treated mesocosms. The two treatments (80 g/L of poultry droppings and pig dung) treated mesocosms have the highest plankton and macro-invertebrates abundance and diversity. On the evenness indices, the highest value was recorded in the control mesocosms (0.496-1.734). This result agreed with Yap *et al.* (2003) opined that diversity indices give better information about the environmental conditions, types of substrata and pollution levels. The authors further stated that substrate and pollution levels of water bodies affect the distribution of plankton and macro-invertebrates. The low species evenness indices of this study might not be unconnected with the pollution of the treated mesocosms as reported by Tsegazeable, (2012) and Kings and Jonathan, (2003). The evenness indices showed that plankton species found in the studied mesocosms were better distributed but macro- invertebrate evenness indices were not evenly distributed. This shift in species abundance can have effects on ecosystem functioning that are as great as those from shifts in species richness (Olivier and Björn, 2004; Rajagopal *et al.,* 2010).

Conclusion

The present study has shown that the quantity of plankton and macro-invertebrates in a simulated chicken manure and pig dung fertilized mesocosms can be influenced to some extent by the type and quantity of manure. High application rate of manure reduces water quality to some extent, duplicates the plankton population and may cause adverse effect. The pond productivity was significantly higher in manure treated mesocosms than control mesocosms. The study revealed that chicken manure was more productive than pig manure however; pig dung even at a higher dose did not adversely affect the environmental water quality parameters. In the two manure (chicken and pig), the chicken manure appeared to be more efficient and effective compared to pig dung. In the present investigation, an application rate of 80 g/L of poultry droppings and pig dung) is recommended in terms of species richness, composition and abundance.

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