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Organic Manures and Phytoplankton Production

A. O. Iyiola[1] and A. P. Ojo-Awo[1*]

[1]*Department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Phytoplankton are primary producers in aquatic ecosystem and play an important role in the food chain or web in aquatic ecosystem. This research compared rate of production of plankton from poultry droppings and cow dung against control (no manure) and the impacts on the physico-chemical parameters. Daily sampling, identification and counting as well as analysis of physico-chemical parameters were carried out. Phytoplankton species observed were Pediastrum, Chlorella, Spirogyra and Closterium. Poultry droppings stimulated the highest production while the least was the control (no manure). The mean values for temperature were 27.4ºC for poultry droppings, 27.1ºC for Cow dung and 27.3ºC for the Control. pH recorded 7.5 for Poultry droppings, 7.0 for Cow dung and 7.1 for the Control. Dissolved oxygen was 5.0 mg/l throughout the culture systems. Ammonia recorded 0.9 mg/l for Poultry droppings, 0.4 mg/l for Cow dung, 0.0 mg/l was recorded for Control. Nitrite was 3.5 mg/l for Poultry droppings, 0.25 mg/l in Cow dung, 0.5 mg/l and 0.1 mg/l in Control. Nitrate was 80 mg/l for Poultry droppings, Cow dung was 22.5 mg/l while 12.5 mg/l was the Control. Poultry droppings produced the highest number of phytoplankton species as a result of the high Nitrate and Phosphate content which is a mineral stimulates phytoplankton production. ANOVA results showed significant differences ($P<0.05$) in phytoplankton production between Poultry droppings, cowdung and control.

Keywords: Phytoplankton; organic manures; water quality.

**Corresponding author: Email: adeyinkaojoawo@gmail.com, adamsovieiyiola@yahoo.com;*

1. INTRODUCTION

The aim of fertilization is to aid production by increasing the quantity of natural food present, this depends on the relative quantity of inorganic nutritive substances available in the manures, adequate temperature and light [1]. Phytoplankton are microscopic plants that float on or near the surface and is characteristic by the greenish colouration of water. They assimilate the nutrients in the manures and their abundance increases, reproducing and forming dense communities on water called a bloom [2]. They are agents of primary production which involves the creation of organic compounds from carbon dioxide and water which is a process that sustains the aquatic ecosystem. They form the base of the food chain and as they multiply they are eaten directly by some fish or by other mostly microscopic aquatic animals called zooplankton. Phytoplankton and zooplankton serve as food for larger aquatic organisms [3]. Organic manures are preferred because it contains all the nutrients needed for biological processes and it releases nutrients into the water.

The productivity of phytoplankton can be related to the type of manure since it produces nutrients for primary production. Manures from chickens, goats, rabbit, sheep, cattle, horses are excellent fertilizers for fish ponds. Manures containing high concentrations of ammonia e.g. Poultry droppings could be toxic to aquatic life if too much of such are added to a pond leading to pollution indiscriminately [4]. Fertilizers may be organic or inorganic each containing varying amounts of Nitrogen, Phosphorus and Potassium. A complete fertilizer contains all three nutrients. Inorganic types of fertilizers are chemical fertilizers which contain nutrients either alone or in combination to make a mixed fertilizer. The composition is always expressed in order of Nitrogen, Phosphorus and Potassium. They can be in the form of liquid or granules.

Nitrogen is not a limiting element in phytoplankton production because it is always present as an element of basic protein in part of living cells and present as Ammonium, Nitrate or Urea in sufficient amounts through natural processes such as animal wastes and decomposition. Phosphorus is the most essential element because it aids plant respiration and stimulates root production. It is present as phosphate, expressed as P_2O_5 or Phosphoric pentoxide. Potassium (K) is needed for the manufacture of carbohydrates and acts as a catalyst in plants. It is expressed as KO or potassium monoxide. It tends to move from the bottom mud to the water and plants readily [1].

Organic fertilizers are natural substances that tend to accelerate the production of phytoplankton or other microscopic animals on which many fish feed more rapidly. They contain low levels of Nitrogen; Phosphorus and Potassium thus larger quantities are added to affect the same level of nutrients as inorganic fertilizers. They have a shorter production cycle than inorganic and may lead to increased filamentous algae growth. Organic fertilization also stimulates the growth of decomposers such as bacteria and fungi. Bacteria and fungi are critical to the breakdown of the toxic waste products that can accumulate with the use of prepared feeds [2,1]. Liming is also essential for the production of phytoplankton because, it increases the pH of bottom mud thereby increasing the availability of phosphorus nutrients in the fertilizer and increases the availability of carbon dioxide for phytoplankton photosynthesis [2]. The amount of lime added will depend on the acidity of the pond mud and the total hardness. Agricultural limestone - $CaCO_3$ or $CaMg\ (CO_3)_2$ is the most common liming material.

There is no general consensus to the quantity of application because of the variation in nutrient components of various manures. It is essential to be specific on the rate application; the rate of application should depend on the prevailing fertility of the culture medium to avoid excessive planktonic bloom which depletes oxygen.

The importance of phytoplankton in an ecosystem cannot be over emphasized and there is need to enhance their population and determine the best suitable manure which stimulates their highest abundance of production. This research compared the effectiveness of poultry droppings, cow dung and control (no manure) in production of phytoplankton and the effects of such manures on the physico-chemical parameters of the culture medium.

2. MATERIALS AND METHODS

2.1 Study Area

The study area lies between semi-savannah zone, south western Nigeria on latitude 7ºN and longitude 3.5ºE, in a controlled indoor laboratory.

2.2 Materials

The materials used were plastic aquaria, Poultry droppings, Cow dung, Water, Beakers, Oxygen test kit, Ammonia, nitrite, nitrate and pH test kit (made by Blagdon), Mecury-in-glass thermometer, Olympus Electric binoculars, Haemacytometer and Scot pro sensitive scale 600 g (made by Ohaus).

2.3 Manure Collection and Nutrient Analysis

The manures were collected, analysed and left to dry because moisture content can also affect the quality of manures [2]. The manures were added at dosage of 57 mg/*l* to 10litres of water. The manures were soaked in water for 2-3 days for the nutrients to filtrate into the water and it was analysed for following nutrients: Nitrogen, Phosphorus, Potassium, Magnesium, Calcium, Sodium and Iron.

2.4 Phytoplankton Collection and Identification

Four variables with five replicates were set up using plastic aquaria and filled with 10 litres of water each. The plastics were labeled A- Poultry droppings, B- Cow dung and C- Water (Control). One liter of green water was added into each of the aquaria to inoculate the system. Phytoplankton abundance was determined daily by measuring 1ml using a haemacytometer. Identification was carried out using guides by Janse Van vuuren et al. [5] and counting was done under Olympus electric binoculars of X40. Phytoplankton species identified were Pediastrum, Chlorella, Spirogyra and Closterium.

2.5 Determination of Physico-chemical Parameters

Parameters considered were Dissolved oxygen, Temperature, Ammonia, Dissolved oxygen, Nitrite, Nitrate and Hydrogen ion concentration. These parameters were monitored daily. Temperature was determined by inserting a mecury-in-glass thermometer (max 120ºC) into each aquaria and left for about five minutes for a steady reading. Dissolved oxygen was determined using Oxygen tetra kit and other parameters were determined using Blagdon test kit.

2.6 Statistical Analysis

Analysis of Variance (ANOVA) was used to compare the mean values of phytoplankton stimulated between the manures and establish significant differences. Microsoft Excel 2010 was used to illustrate all graphical representation.

3. RESULTS

3.1 Physico-chemical Parameters

The mean values and standard error of physico-chemical parameters for each treatment are shown in Table 1.

Water temperature recorded was 27.4ºC in poultry droppings, 27.1ºC in cow dung and 27.3ºC in the control (fig 1). Dissolved oxygen 5.0 mg/*l* throughout the treatments (Fig. 2), pH was 7.5 in poultry droppings, 7.0 in cow dung and 7.0 in the control (Fig. 1). Ammonia was 0.9 mg/*l* in poultry droppings, 0.4 mg/*l* in cow dung and 0.0 mg/*l* in the control (Fig. 2). Nitrite was 3.5 mg/*l* in poultry droppings, 0.25 mg/*l* in cow dung and 0.1 mg/*l* in the control (Fig. 3) and Nitrate ranges was 80 mg/*l* in poultry droppings, 25.0 mg/*l* in cow dung and 12.5 mg/*l* in the control (Fig. 3).

3.2 Manure Nutrient Analysis

The Table 2 shows the nutrients present in the manures used. Nutrients recorded the highest values in Poultry droppings (A), followed closely by Cow dung (B) and the least was the control (C).

3.3 Phytoplankton Collection and Identification

The table below shows the species of phytoplankton produced identified and counted from the manure samples. The total abundance of phytoplankton was 10966, treatment A which is poultry droppings stimulated an abundance of 5141 phytoplankton comprising of Pediastrum 1180, Chlorella 1318, Spirogyra 1208 and Closterium 1435 species. Treatment B which is cow dung stimulated an abundance of 3674 phytoplankton comprising of Pediastrum 699, Chlorella 1084, Spirogyra 1232 and Closterium 859 species. Treatment C which is control stimulated an abundance of 2151 phytoplankton comprising of Pediastrum 490, Chlorella 543, Spirogyra 616 and Closterium 502 species. From all the treatments, Pediastrum accounted for a total abundance of 2369 phytoplankton, Chlorella accounted for 2945, Spirogyra 2856 and Closterium accounted for 2796 species.

Table 1. Mean values for physico-chemical parameters measured for various treatments

Physico-chemical parameters	Treatments		
	Poultry droppings	Cow dung	Control
Temperature (ºC)	27.4±1.1	27.1±0.5	27.3±1.9
Hydrogen ion conc	7.5±1.2	7.0±0.8	7.0±1.2
Dissolved oxygen (mg/l)	5.0±1.1	5.0±1.1	5.0±1.1
Ammonia (mg/l)	0.9±0.1	0.4±0.2	0.0±0.0
Nitrite (mg/l)	3.5±1.22	0.25±1.0	0.1±0.3
Nitrate (mg/l)	80±1.3	25.0±1.1	12.5±1.4

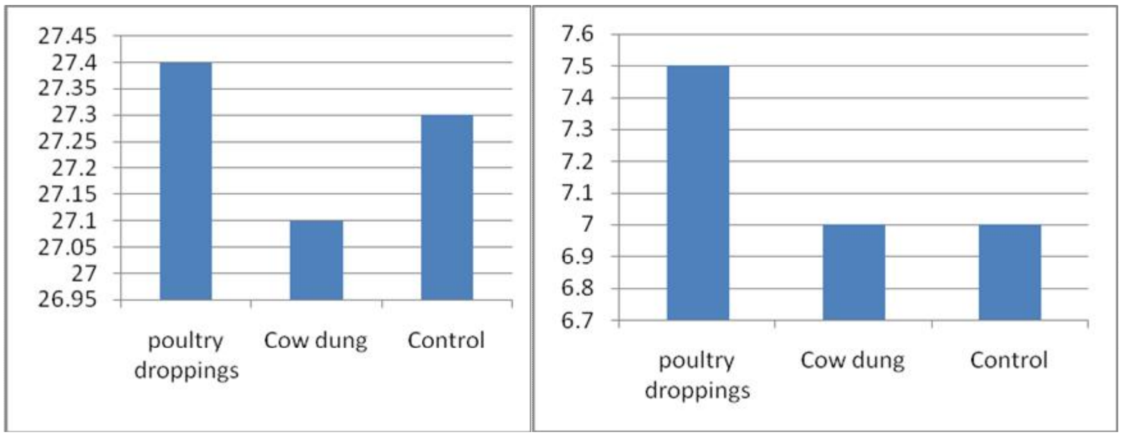


Fig. 1. Mean values of temperature and hydrogen ion conc from the treatments

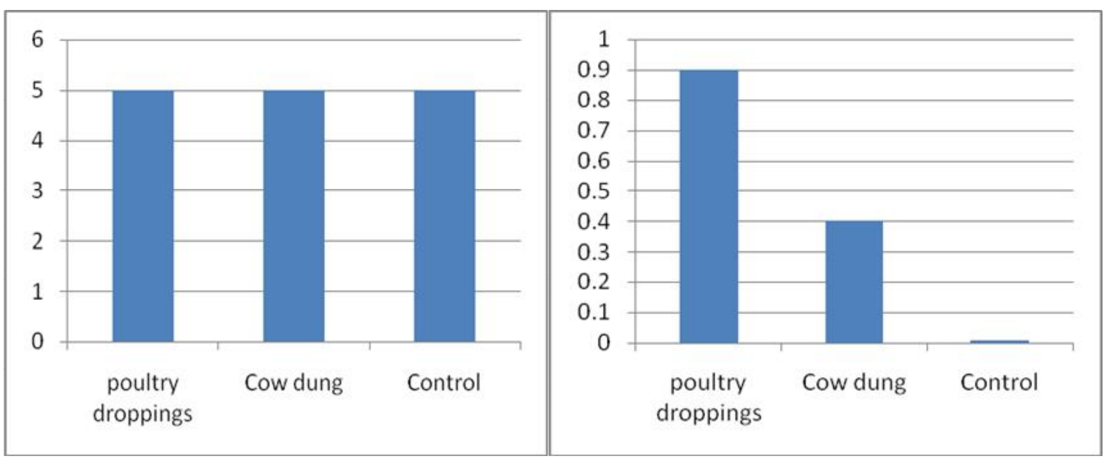
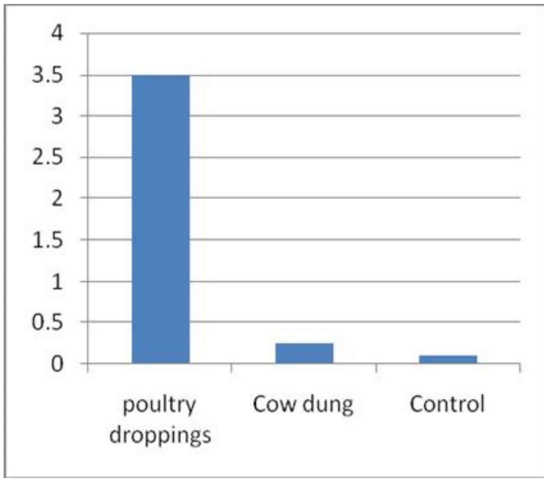


Fig. 2. Mean values of dissolved oxygen and ammonia (mg/L) from the treatments

Table 2. Nutrient analysis from the various treatments used

Nutrients	A	B	C
% N	2.34	0.57	0.1
% P	0.24	0.04	0.0
% K	0.03	0.03	0.0
% Ca	0.10	0.10	0.1
% Mg	0.04	0.03	0.0
Na (mg/kg)	64.91	57.20	2.0
Fe (mg/kg)	15.63	13.91	0.00

Key A – Poultry droppings Na – Sodium Mg – Magnesium Ca – Calcium B – Cow dung P – Phosphorus N – Nitrogen C – Control (water) K – Potassium Fe - Iron



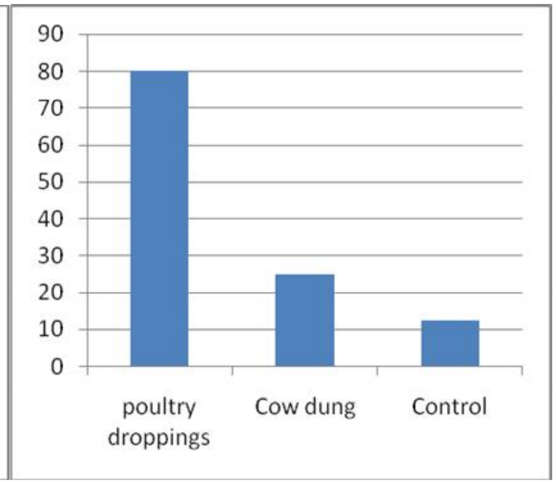


Fig. 3. Mean values of nitrite and nitrate (mg/L) from the three treatments

4. DISCUSSION

The mean temperature of the culture media ranged between 27.1 - 27.4ºC (Table 1) which is within the required rate as stated by Bocek and Gray [2], Wurtz [6] that the optimum temperature for fresh water organisms is between 25 - 32ºC. Mean hydrogen ion concentration ranged between 6.9 - 7.5 which is conducive for phytoplankton production, as discussed by Reginal and Donald, [1] and Wurtz [6] that the recommended pH range for culture of freshwater organisms is between 6.5 - 9.0. Mean dissolved oxygen is 5.0 mg/*l* and it is conducive for phytoplankton production as discussed by Wurtz [6] which recommended that the range for oxygen in freshwater culture system must not be less than 5.0 mg/*l*. Ammonia ranges between 0.0 – 0.9 mg/*l* (Table 1). As discussed by Bocek and Gray [2], the permissible ammonia level in freshwater ponds is 0.1 mg/*l*. Ammonia is very dangerous. Ammonia level in culture systems must be reduced to 0 mg/*l* at all times by increased aeration and addition of freshwater [2]. Ammonia level was highest in treatment A (poultry droppings) than B and C and was reduced gradually by constant addition of freshwater [2,6]. Nitrite levels recorded during the experiment ranged between 0.1 – 3.5 mg/*l* (Table 1) which is a little high for phytoplankton production because an ideal water condition according to Wurtz [6] is 0.0 mg/*l*. During the experiment, nitrite levels were high and reduced daily as freshwater was added, but level above 4.0 mg/*l* is very toxic and must be reduced immediately by addition of freshwater [6].

Nitrate is a major macro nutrient used by phytoplankton to grow and levels above 100 mg/*l* will encourage the growth of dangerous algae which affects pond plants. Levels recorded during the experiment ranged between 12.5 – 80 mg/*l*, Nitrate level recorded for poultry droppings (treatment A) was high at 80 mg/*l* (Table 1) and therefore stimulated the highest population of phytoplankton (Table 3), followed by cow dung and control. Treatment C (control) produced the least number of phytoplankton. From the nutrient analysis of manures, Phosphates which is a principal element in plant respiration and root formation [1] had the highest concentration in poultry droppings (Table 2) thereby stimulated the highest population of phytoplankton species (Table 1) and control which had no Phosphate concentration produced the least number of species. These showed that poultry dropping is best for phytoplankton production based on its nutrient composition and fertilization with essential so as to stimulate optimal production of natural food in an aquatic system [6].

From ANOVA results, There are significant differences in the number of Pediastrum produced by poultry droppings ($P<0.05$) ($F=3.284$) and cow dung ($P<0.05$) ($F=2.583$) in comparison with the control; There are significant differences in the number of Chlorella produced by poultry droppings ($P<0.05$) ($F=4.945$) and cow dung ($P<0.05$) ($F=4.871$) in comparison with the control; There are significant differences in the number of Spirogyra produced by poultry droppings ($P<0.05$) ($F=4.544$) and cow dung ($P<0.05$)($F=4.50$) in comparison with the control; There are significant differences in the number of Closterium produced by poultry droppings ($P<0.05$) ($F=2.767$) and cow dung ($P<0.05$) ($F=2.453$) in comparison with the control.

Table 3. Total number of phytoplankton produced

Phytoplankton	Poultry droppings	Cow dung	Control (water)	Total
Pediastrum	1180	699	490	2369
Chlorella	1318	1084	543	2945
Spirogyra	1208	1032	616	2856
Closterium	1435	859	502	2796
Total	5141	3674	2151	10966

5. CONCLUSION AND RECOMMENDATIONS

It is evident that the nutrient quality of organic manures plays a direct impact on the rate of production of phytoplankton. The manures promotes root production, growth and production of phytoplankton which keeps the food chain / food web alive as primary producers thereby sustaining other forms of life such as zooplankton and fish which dependent on each other. Poultry dropping still remain the best organic material for fertilization but Ammonia content must be put into consideration by addition of fresh water.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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