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Comparative Nutrient (NPK) Analysis of Chicken Manure and Catfish Effluent as Organic Fertilizer Sources

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Abstract: **This study comparatively evaluated the nutrient composition of chicken manure and catfish effluent by determining their nitrogen (N), phosphorus (P), and potassium (K) contents, with the aim of assessing their relative potential as organic nutrient sources for sustainable crop production. Samples of chicken manure and catfish effluent were collected in triplicate from farms and ponds in Gobirawa, Zaria, Kaduna State, and analysed for NPK content using standard laboratory procedures. Data were summarised as mean ± standard deviation and compared using an independent-samples t-test at $p < 0.05$. Chicken manure consistently contained significantly higher concentrations of all three macronutrients than catfish effluent (nitrogen: $t(4) = 83.56$, $p < 0.001$; phosphorus: $t(4) = 44.39$, $p < 0.001$; potassium: $t(4) = 42.90$, $p < 0.001$). Mean nitrogen, phosphorus and potassium contents of chicken manure were 2.80 ± 0.03%, 1.50 ± 0.03% and 1.10 ± 0.02%, respectively (total NPK = 5.40%), compared with 1.20 ± 0.02%, 0.65 ± 0.02% and 0.48 ± 0.02% for catfish effluent (total NPK = 2.33%). Within each source, nitrogen constituted the largest share of the nutrient pool (51.8% in chicken manure and 51.5% in catfish effluent), followed by phosphorus (27.8% and 27.9%) and potassium (20.4% and 20.6%). When considered as a combined pool, chicken manure accounted for approximately 70% of the total nitrogen, phosphorus and potassium, while catfish effluent contributed about 30%. The study concludes that although both by-products possess fertilizer value, chicken manure is a significantly richer source of NPK and is more suitable where rapid nutrient supplementation is required, while catfish effluent remains a useful organic amendment that can complement chicken manure in integrated nutrient management systems.**

Keywords: **chicken manure; catfish effluent; organic fertilizer; NPK; nutrient recycling; sustainable agriculture; independent t-test.**

1. INTRODUCTION

Rapid population growth has intensified the global demand for food, prompting increased reliance on chemical fertilizers to sustain crop yields. However, the continuous use of synthetic fertilizers has been linked to soil degradation, water pollution, loss of soil biodiversity and rising production costs [1]. These concerns have redirected attention toward organic nutrient sources derived from agricultural and aquaculture wastes, which improve soil structure, enhance microbial activity, increase water-holding capacity and release nutrients gradually while reducing losses through leaching and runoff [2].

Chicken manure, a by-product of poultry farming, is widely regarded as one of the richest organic fertilizers because poultry excrete urine and faeces together, limiting nutrient losses relative to other livestock manures [2]. It supplies substantial quantities of nitrogen, phosphorus and potassium (NPK), the primary macronutrients required for plant growth: nitrogen drives vegetative growth and chlorophyll formation, phosphorus supports root development and energy transfer, and potassium regulates water balance, enzyme activation and disease resistance [3]. Catfish effluent, the wastewater discharged from aquaculture systems, similarly contains dissolved nutrients originating from fish excreta, uneaten feed and microbial decomposition, and represents a growing source of nutrient-rich wastewater that can be recycled for crop production rather than discharged into the environment [4,5].

Because chicken manure is a concentrated solid waste while catfish effluent is a dilute liquid waste, the two differ considerably in nutrient concentration, nutrient release pattern and mode of application. Poultry manure generally contains greater total nitrogen, phosphorus and potassium than aquaculture wastewater, although nutrients in the latter are often more readily plant-available because they occur largely in dissolved form [6]. Despite the growing interest in both materials as alternatives to inorganic fertilizer, there remains limited comparative information on their nutrient composition, and many farmers apply them without adequate knowledge of their NPK concentrations, risking either nutrient deficiency or over-application [7,8].

This study was therefore designed to determine and compare the nitrogen, phosphorus and potassium contents of chicken manure and catfish effluent, in order to establish their relative potential as organic fertilizers and provide evidence to guide their effective utilisation in sustainable crop production. Specifically, the study sought to (i) determine the nitrogen, phosphorus and potassium contents of chicken manure and catfish effluent; (ii) compare the NPK values obtained from the two sources; and (iii) evaluate their relative suitability as organic fertilizers.

2. MATERIALS AND METHODS

2.1 Study Area and Sample Collection

The study was carried out in Gobirawa, Zaria, Kaduna State, a community located behind the Nuhu Bamalli Polytechnic, Zaria (UPE) main campus. Chicken manure was obtained from selected poultry farms, while catfish effluent (approximately 10 L per collection) was obtained from catfish production ponds within the same locality. Samples of each material were collected in triplicate from different farms/ponds and pooled to obtain a composite sample prior to laboratory analysis. All samples were transported to the Department of Biochemistry, College of Agriculture, Ahmadu Bello University, Zaria, for nutrient analysis.

2.2 Sample Preparation

Chicken manure was air-dried at room temperature for seven days and subsequently oven-dried at 65 °C to constant weight. The dried samples were ground with a mortar and pestle and sieved through a 2 mm mesh prior to analysis. Catfish effluent samples were filtered through Whatman No. 42 filter paper to remove suspended solids and stored at 4 °C until analysis.

2.3 Determination of Nitrogen

Total nitrogen was determined by the Kjeldahl digestion method as described by AOAC [9]. One gram of dried chicken manure or 50 mL of catfish effluent was digested with concentrated sulphuric acid and a catalyst mixture until a clear digest was obtained. The digest was diluted, distilled with sodium hydroxide, and the liberated ammonia trapped in boric acid containing mixed indicator before titration against standard hydrochloric acid. Nitrogen content (%) was calculated from the titre values, the normality of the acid and the sample weight.

2.4 Determination of Phosphorus

Available phosphorus was determined colorimetrically by the molybdenum blue method. Digested samples were reacted with ammonium molybdate reagent, and colour was allowed to develop for 30 minutes before absorbance was measured at 660 nm using a spectrophotometer. Phosphorus concentration was read from a standard calibration curve.

2.5 Determination of Potassium

Potassium was determined by flame photometry using the digests prepared for phosphorus analysis. The flame photometer was calibrated with standard potassium solutions before sample aspiration, and potassium concentration was read directly from the calibration curve.

2.6 Quality Control and Data Analysis

All analyses were performed in triplicate using analytical-grade reagents, with instruments calibrated and blank determinations run alongside each batch. Nutrient data for chicken manure and catfish effluent were summarised as mean ± standard deviation (SD) for each replicate set. An independent-samples t-test was used to compare the mean nitrogen, phosphorus and potassium contents between the two sources, with differences considered statistically significant at $p < 0.05$. All samples were collected with the permission of farm owners, and laboratory waste was disposed of in accordance with standard environmental and safety procedures.

3. RESULTS

Chicken manure recorded higher NPK values than catfish effluent across every replicate (Table 1). For nitrogen, all three chicken-manure readings (2.78, 2.83 and 2.79%) were more than double the corresponding catfish-effluent readings (1.18, 1.22 and 1.20%), and the same pattern held for phosphorus and potassium.

Table 1. Raw NPK replicate values for chicken manure (CM) and catfish effluent (CE), % w/w.

Nutrient	CM Rep 1 (%)	CM Rep 2 (%)	CM Rep 3 (%)	CE Rep 1 (%)	CE Rep 2 (%)	CE Rep 3 (%)
Nitrogen (N)	2.78	2.83	2.79	1.18	1.22	1.20
Phosphorus (P)	1.48	1.53	1.49	0.63	0.67	0.65
Potassium (K)	1.09	1.12	1.10	0.46	0.50	0.48

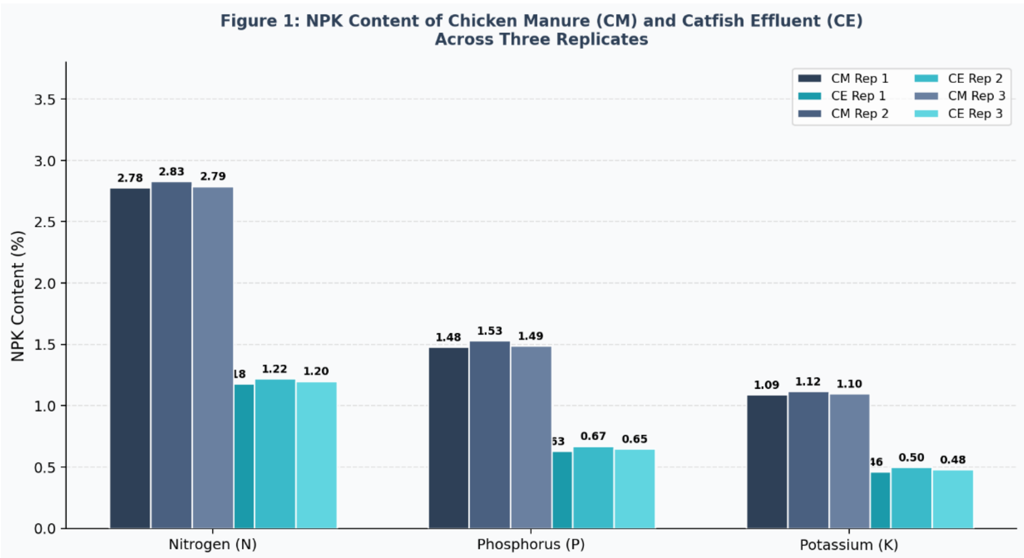

Figure 1. Mean NPK content of chicken manure and catfish effluent.

An independent-samples t-test confirmed that chicken manure had significantly higher mean concentrations than catfish effluent for all three nutrients (Table 2): nitrogen (2.80 ± 0.03% vs 1.20 ± 0.02%; $t(4) = 83.56$, $p < 0.001$), phosphorus (1.50 ± 0.03% vs 0.65 ± 0.02%; $t(4) = 44.39$, $p < 0.001$) and potassium (1.10 ± 0.02% vs 0.48 ± 0.02%; $t(4) = 42.90$, $p < 0.001$). The very low within-group variability (SD ≤ 0.03% for all nutrients) relative to the between-group differences accounts for the high t-values obtained.

Table 2. Independent-samples t-test comparing mean NPK content of chicken manure (CM) and catfish effluent (CE). ** = significant at p < 0.001.

Nutrient	CM Mean ± SD (%)	CE Mean ± SD (%)	t (df = 4)	p-value	Sig.
Nitrogen (N)	2.80 ± 0.03	1.20 ± 0.02	83.56	<0.001	**
Phosphorus (P)	1.50 ± 0.03	0.65 ± 0.02	44.39	<0.001	**
Potassium (K)	1.10 ± 0.02	0.48 ± 0.02	42.90	<0.001	**

Expressing each nutrient as a percentage of the total NPK content within its own source (Table 3) showed that nitrogen dominated the nutrient pool of both materials — about 52% in chicken manure and 51% in catfish effluent — followed by phosphorus (about 28% in both) and potassium (about 20-21% in both). This indicates that, irrespective of which organic input is applied, nitrogen will always be supplied in the greatest proportion, followed by phosphorus and then potassium.

Table 3. NPK values and percentage contribution to total nutrient pool per source. CM = chicken manure; CE = catfish effluent.

Nutrient	CM Mean (%)	% of CM Total NPK	CE Mean (%)	% of CE Total NPK
Nitrogen (N)	2.80	51.8%	1.20	51.5%
Phosphorus (P)	1.50	27.8%	0.65	27.9%
Potassium (K)	1.10	20.4%	0.48	20.6%
Total NPK	5.40	100.0%	2.33	100.0%

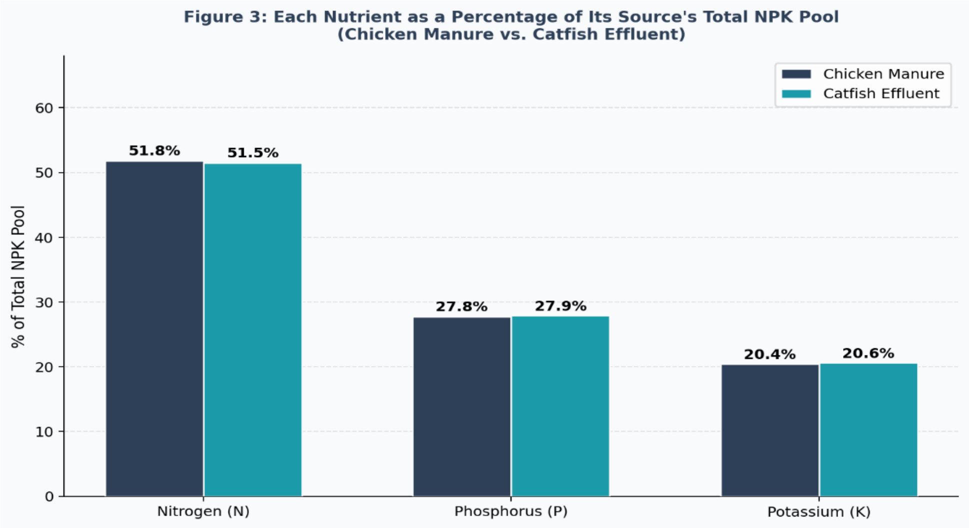

Figure 2. Percentage contribution of each nutrient to the total NPK pool within each source.

When both sources were considered together as a combined nutrient pool (Table 4), chicken manure contributed approximately 70% of the combined nitrogen, phosphorus and potassium, while catfish effluent contributed the remaining 30% in each case — indicating that, in any farming system using both inputs, chicken manure supplies roughly two-thirds of the total nutrient load.

Table 4. Relative percentage contribution of each source to the combined NPK pool.

Nutrient	CM Mean (%)	CM % of Combined	CE Mean (%)	CE % of Combined
Nitrogen (N)	2.80	70.0%	1.20	30.0%
Phosphorus (P)	1.50	69.8%	0.65	30.2%
Potassium (K)	1.10	69.7%	0.48	30.3%

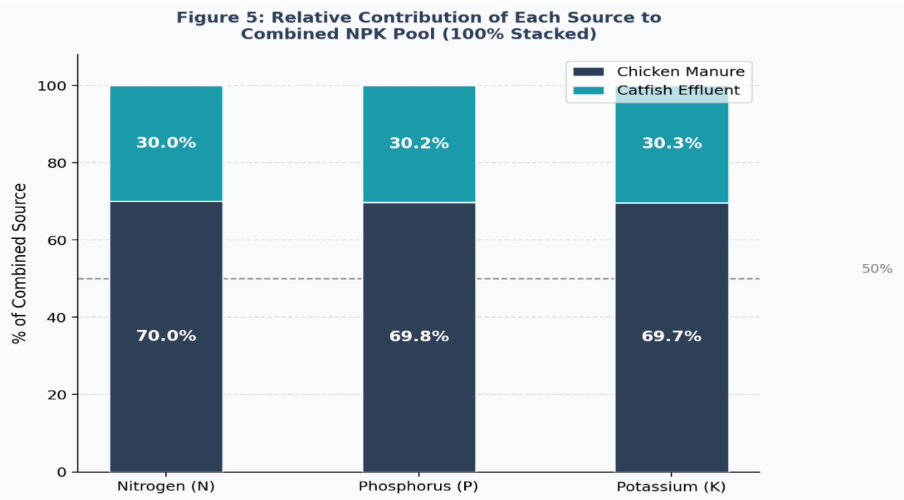

Figure 3. Relative contribution of chicken manure and catfish effluent to the combined NPK pool.

4. DISCUSSION

Chicken manure contained a significantly higher nitrogen concentration (2.80 ± 0.03%) than catfish effluent (1.20 ± 0.02%; $t(4) = 83.56$, $p < 0.001$), indicating a greater capacity to support vigorous vegetative growth. This agrees with Agbede [10], who reported that poultry manure significantly enhances nutrient availability because of its rich nitrogen content, and with Erhunmwunse, Olayinka and Atoloye [11], who found that poultry manure releases substantial amounts of nitrogen into the soil. The comparatively lower nitrogen content of catfish effluent may reflect nutrient dilution in the water-based system, consistent with the observations of Syamsia et al. [12].

Phosphorus concentration was similarly and significantly higher in chicken manure (1.50 ± 0.03%) than in catfish effluent (0.65 ± 0.02%; $t(4) = 44.39$, $p < 0.001$), suggesting greater potential to support root development, flowering and seed formation [8]. This finding is consistent with Erhunmwunse et al. [11], who reported high phosphorus availability in poultry manure compost, while the lower phosphorus content of catfish effluent aligns with Syamsia et al. [12], who found that aquaculture wastewater contains useful but comparatively lower phosphorus concentrations than solid organic manures.

Potassium followed the same trend, with chicken manure (1.10 ± 0.02%) significantly exceeding catfish effluent (0.48 ± 0.02%; $t(4) = 42.90$, $p < 0.001$). Potassium is important for disease resistance, enzyme activation and overall plant health, and the higher content in chicken manure agrees with Yertayeva et al. [13], who reported that poultry manure contributes significant amounts of potassium and improves soil nutrient status. Fish-culture wastewater, by contrast, generally contains lower potassium levels, as also noted by Syamsia et al. [12].

Nitrogen constituted the largest share of the nutrient pool in both materials, accounting for roughly 52% of total NPK, followed by phosphorus (about 28%) and potassium (about 20%). This pattern is consistent with Ndiaye et al. [14], who reported that nitrogen is typically the dominant macronutrient in animal-derived organic fertilizers. When both inputs were compared, chicken manure contributed approximately 70% of the combined nutrient pool against 30% for catfish effluent, supporting the conclusion of Agbede [10] that poultry manure remains among the most nutrient-dense organic fertilizers available to farmers. Although catfish effluent contributes appreciably less on a concentration basis, larger application volumes would be required to match the nutrient levels supplied by chicken manure.

Overall, these findings confirm that chicken manure is a richer source of nitrogen, phosphorus and potassium than catfish effluent, while catfish effluent retains value as a nutrient source for integrated nutrient recycling. As reported by Syamsia et al. [12], fish effluents can serve as useful nutrient sources in crop production when properly managed, and the combined use of chicken manure and catfish effluent may therefore promote both sustainable agriculture and efficient waste utilisation.

5. CONCLUSION AND RECOMMENDATIONS

Both chicken manure and catfish effluent are valuable organic nutrient sources capable of supplying nitrogen, phosphorus and potassium for crop production. Chicken manure contains significantly higher concentrations of all three macronutrients and is a more concentrated, efficient organic fertilizer, whereas catfish effluent, though less concentrated, remains a useful amendment that also serves as a sustainable means of managing aquaculture wastewater. Recycling both agricultural and aquaculture wastes in this way contributes to improved nutrient cycling, reduced environmental pollution and more sustainable agricultural development.

Based on these findings, it is recommended that: (i) chicken manure be promoted as an effective organic fertilizer, particularly for nutrient-deficient soils; (ii) catfish effluent be applied as a liquid organic fertilizer rather than discharged into the environment, so as to minimise water pollution while recycling nutrients; (iii) farmers integrate chicken manure and catfish effluent to achieve more balanced nutrient availability; and (iv) further studies examine the effects of both materials on crop yield, soil microbial activity and long-term soil fertility under varying application rates and cropping systems.

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