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Toxicological Assessment of Potash Exposure Using Haematological and Differential Leucocyte Biomarkers in Clarias Gariepinus

Patani, Dudutari Edmund[1*], Eneni Aya-Ebi Okubo[2], Seigbakumoh, Josephine Ogbogene[2], Patani, Timipa Juliet[3]

1. *Department of Biology, Faculty of Science, Bayelsa Medical University, Yenagoa, Nigeria.*
2. *Department of Pharmacology and Toxicology, Faculty of Pharmaceutical Sciences Bayelsa Medical University, Yenagoa, Nigeria.*
3. *Department of Biology, Faculty of Science, Bayelsa Medical University, Yenagoa, Nigeria.*
4. *Department of Medical Microbiology & Public Health, Faculty of Science, Niger Delta University, Amassoma, Nigeria.*

Abstract
Potash is a potassium-rich alkaline substance that may enter aquatic environments through domestic and industrial activities, potentially affecting fish health. This study evaluated the effects of prolonged potash exposure on haematological parameters and differential leucocyte counts of Clarias gariepinus. A total of 25 healthy Clarias gariepinus were exposed to 0.00, 30.2, 45.4 and 75.6 mg/L potash for 21 days. Blood samples collected after exposure were analyzed for white blood cell (WBC), red blood cell (RBC), haemoglobin (HGB), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), platelet (PLT), neutrophil (NEU), lymphocyte (LYM), monocyte (MONO) and eosinophil (EOS) counts. Data were expressed as mean ± standard deviation and analyzed using one-way ANOVA followed by Tukey's HSD test at $p < 0.05$. Potash exposure produced significant alterations in several haematological indices. WBC decreased from 43.90 ± 41.22 in controls to 12.44 ± 3.28 at 75.6 mg/L, while RBC and PCV generally declined following exposure. Platelet count increased to 192.62 ± 9.24 at 75.6 mg/L. Differential leucocyte counts showed reduced neutrophils, monocytes and eosinophils, accompanied by increased lymphocytes. The findings demonstrate that prolonged potash exposure disrupts haematological homeostasis and leucocyte distribution in Clarias gariepinus, indicating physiological stress and potential haematotoxicity. Controlled disposal of potash-containing wastes and routine haematological monitoring of exposed fish are recommended.
Key words: *Clarias gariepinus; potash; haematotoxicity; differential leucocyte toxicity; aquatic toxicology; fish health.*

I. Introduction

Potash is a potassium-rich alkaline material used in domestic, agricultural and industrial activities (APHA et al., 2017). Depending on its source and composition, potash may contain potassium carbonate (K_2CO_3) and other potassium salts. When discharged into aquatic environments, soluble potassium compounds can increase potassium concentrations, alkalinity and water pH, potentially disturbing the physicochemical conditions required for normal aquatic life (WHO, 2022). Fishes depend on stable environmental conditions for osmoregulation, ionic balance, acid-base regulation and respiration. Consequently, prolonged exposure to elevated concentrations of alkaline potassium compounds may impose physiological stress and impair normal biological functions (OECD, 2025).

Aquatic contaminants can affect organisms at molecular, cellular, physiological and ecological levels, thus making fishes valuable indicators of environmental pollution (Burgos-Aceves et al., 2019; Gallego-Rios et al., 2021). *Clarias gariepinus* is particularly suitable for aquatic toxicological investigations because of its ecological adaptability, wide distribution, economic importance and extensive consumption in Nigeria. Its exposure to contaminated water can result in measurable haematological, biochemical, oxidative and histopathological alterations (Akinrotimi et al., 2021; Melefa & Okoloye, 2023; Moussa et al., 2022). These characteristics make C. gariepinus an important model for evaluating the biological consequences of chemical contaminants in freshwater ecosystems.

Experimental evidence has established that potash can adversely affect freshwater fish. Vijayavel and Balasubramanian (2007) reported concentration-dependent toxicity of potash in *Oreochromis mossambicus*, including effects on food intake, growth and feed conversion. These findings indicate that potash toxicity may occur at sublethal levels and may become more deleterious under prolonged exposure. Excessive potassium concentrations can interfere with ionic gradients, while increased alkalinity and pH may impose additional demands on gill-mediated ion regulation and acid-base balance (WHO, 2022). Persistent disruption of these processes may increase metabolic demands and compromise growth, reproduction and immune function.

Haematological parameters provide sensitive indicators of physiological stress in fish. Changes in red blood cell count, haemoglobin concentration and packed cell volume can reflect disturbances in oxygen transport and erythropoietic activity, whereas alterations in leucocyte profiles may indicate stress and changes in immune function (Fazio, 2019; Seibel et al., 2021). Studies involving C. gariepinus exposed to pesticides, industrial effluents and contaminated aquatic environments have reported significant alterations in haematological and biochemical biomarkers (Akinwande et al., 2020; Oyeniran et al., 2021; Akinrotimi et al., 2021). Heavy-metal exposure has similarly been associated with oxidative stress, biochemical disturbances and tissue damage in this species (Farombi et al., 2007; Kumar et al., 2020). These findings support the use of haematological indices and differential leucocyte counts as practical biomarkers for detecting sublethal toxic effects.

The ecological implications of potash contamination may extend beyond directly exposed fish. Aquatic ecosystems consist of interconnected food webs involving primary producers, plankton, benthic organisms, invertebrates and fish. Changes in water chemistry can impact primary productivity, aquatic community structure and food availability, potentially affecting organisms at higher trophic levels. Pollution-related changes in aquatic communities can consequently influence ecosystem productivity and fisheries resources (Oyeniran et al., 2021; Moussa et al., 2022). This phenomenon is of particular concern in Nigeria, where freshwater ecosystems provide fish for household consumption, commercial fisheries and local livelihoods.

The human food-chain dimension also warrants consideration because *Clarias gariepinus* is widely consumed and can accumulate environmental contaminants from polluted aquatic systems. Recent Nigerian studies have documented heavy metals, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in C. gariepinus, with some studies identifying potential dietary exposure and human-health risks (Egun et al., 2023; Ololade et al., 2024, 2025a, 2025b; Taiwo et al., 2025). These findings demonstrate that deterioration of aquatic environments can have negative consequences beyond fish health and may become a food-safety concern where persistent contaminants enter edible fish tissues.

Despite increasing evidence concerning chemical contamination of Nigerian aquatic ecosystems, relatively limited information is available on the prolonged effects of potash on the haematological and differential leucocyte responses of *Clarias gariepinus*. Existing research is centered largely on metals, pesticides, petroleum hydrocarbons and industrial effluents (Akinwande et al., 2020; Akinrotimi et al., 2021; Oyeniran et al., 2021; Ololade et al., 2025a). Investigating prolonged potash exposure is therefore necessary to identify sublethal physiological effects that may not be apparent from mortality-based toxicity assessments.

The present study evaluates the effects of prolonged exposure to selected concentrations of potash on the haematological parameters and differential leucocyte counts of *Clarias gariepinus*. The study aims to determine whether potash exposure produces measurable concentration-dependent alterations in erythrocytic and leucocytic indices and to provide evidence concerning its potential implications for fish health, aquatic ecosystem integrity and the safety of fish as an important human food resource.

II. MATERIALS AND METHODS

Source of Fish and Transportation

A total of twenty-five (25) healthy juvenile *Clarias gariepinus* (African catfish) weighing between 1000 g to 1500 g per weight were obtained from Ikuligan Farm at Agudama Epie, within Yenagoa metropolis of Bayelsa State for the sublethal bioassay test. Fish were transported in plastic cans covered with fishing nets to the wet laboratory of the Department of Biology, Faculty of Science, Bayelsa Medical University, Bayelsa State, Nigeria for the experiment.

2.1 Source of Chemical (Potash)

The test chemical, potash (KCl), a white crystalline solid with a molar mass of 74.555 $gmol^{-1}$ and density of 1.984 g/cm^3 was purchased from a chemical store at Swali market, within Yenagoa metropolis of Bayelsa State, Nigeria.

2.2 Fish Acclimatization

Experimental fish were acclimatized in four plastic aquaria for a period of two weeks (14 days). Within this period, a renewal bioassay was carried out, that is, water was changed daily (24 hours interval) and the plastic aquaria were properly aerated and cleaned, while maintaining equal light and dark conditions. Fish were also fed with compounded fish feeds at 5 % body weight daily at 11:00 hours. Feeding was discontinued 24 hours before the start of the main experiment. Fish were considered healthy and fit for the definitive test with mortality rate less than 5 %.

2.3 Range Finding Test

The sublethal concentration needed for the definitive test was determined following a trial experiment, also known as range finding test. Three small portions of the test chemical substance (potash) measuring 2g, 3g and 5g were measured using an electronic weighing balance and dissolved differently in three aquaria containing 30 L of water each. Three (3) juveniles of *Clarias gariepinus* was then randomly selected and exposed to the three different arbitral concentrations of the toxicant following a static renewal bioassay for 72 hours. The concentrations obtained during the trial or range finder test, were later converted and presented in mg/L following the method and formula described by Inyang, (2008) where:

$\mathbf{N_1\,V_1 = N_2V_2}$

N_1 = manufacturers concentration (1.984 g/cm^3)

V_1 = concentration of the test solution preferred

N_2 = quantity of the original solution added

V_2 = quantity of the test solution

The concentrations obtained during the trial test were further converted to milligram per litre as stated earlier using the formula described by Inyang, (2008). Thus, the sublethal concentrations for the main experiment are thus: 30.2 mg/L, 45.4 mg/L and 75.6 mg/L.

2.4 Definitive Experiment

The sublethal test was a completely randomized, static bioassay experiment and the test was conducted under room temperature following the method described by Inyang, (2008). During the sublethal test, Fish were randomly assigned into control and treatment groups. The sublethal experiment was made up of two main groups, that is, one (1) control group having four replicates with one (1) fish in each aquarium, labeled T_0R_1-T_0R_4 and three (3) treatment groups of four (4) replicates, having one (1) fish in each aquarium and was labeled thus: T_1R_1-T_1R_4, T_2R_1-T_2R_4 and T_3R_1-T_3R_4.

Fish in the treatment groups were exposed to three different concentrations (30.2 mg/L, 45.4 mg/L and 75.6 mg/L.) of the test chemical which was obtained from the range finder test for twenty-one (21) days (3 weeks), while the control group had no chemical exposure during the period of the sublethal experiment. Also, during the test, tap water (30 L) and test chemical concentrations were renewed daily at 11:00 hours. A total of sixteen (16) plastic aquaria were used for the sublethal experiment with each aquarium having one (1) fish, making a total of sixteen (16) experimental fish, including the control. The holding plastic aquaria were properly aerated and regularly cleaned while equal light and dark conditions were maintained throughout the period of the experiment. Fish were also fed with compounded fish feeds at 5 % body weight daily at 11:00 hours during the period of the sublethal experiment.

2.5 Sample Collection, Preparation and Laboratory Analysis

2.5.1 Blood

At the end of the twenty-one (21) days exposure period, blood samples of fish were collected from the dorsal aorta using hypothermic needles and syringes and put inside EDTA bottles. These bottles have anticoagulant that prevents blood clot. The samples were put inside a refrigerator until it was sent to Federal Medical Centre, Yenagoa for haematological analysis. Haematological parameters such as WBC, RBC, HGB, PCV, MCV, MCH, and Platelet were analyzed in this study. On the other hand, differential leucocytes parameters also analyzed in this study include: Neutrophils (NEU), Lymphocytes (LYM), Monocytes (MONO) and Eosinophils (EOS).

2.6 Statistical Analysis

The data gotten from the study was subjected to statistical analysis such as:

i. One-way analysis of variance (ANOVA), conducted to see if significant differences exist between the measured parameters.
ii. Means and Standard Deviations were also calculated from the data derived from the analysis of the various experimental groups.
iii. A Post Hoc Test (Turkey HSD test) was conducted to separate means between groups and determine their interrelatedness.

All statistical analysis was done using the SPSS (Statistical Package for Social Sciences) statistical tool kit version 20®.

III. RESULTS AND DISCUSSIONS

3.1 Results on Haematological Parameters

The relative activities of haematological indices (WBC, RBC, HGB, PCV, MCV, MCH, and Platelet) and differential counts of juveniles of *Clarias gariepinus* after 21 days of exposure to potash are presented in Tables

1 and 2. From the result presented, there is a significant (P<0.05) decline in the values of WBC, RBC, HGB, PCV, MCH, and MCHC. The values of WBC declined from 43.90±41.22 mg/L (control) to 12.44±3.28 at 75.6 concentration; RBC from 2.01±0.75 mg/L (control) to 1.67±1.14 mg/L at 75.6 concentration; HGB from 10.38±1.07 mg/L (control) to 9.62±1.93 mg/L at 75.6 concentration; PCV from 21.34±4.14 mg/L (control) to 14.78±3.62 mg/L at 75.6 concentration; MCH from 63.26±5.27 mg/L (control) to 47.53±3.94 mg/L at 75.6 concentration; and MCHC from 48.31±5.71 mg/L (control) to 38.26±7.57 mg/L at 75.6 concentration of toxicant. On the other hand, the values of MCV and Platelet recorded high from 131.69±4.81 mg/L (control) to 145.83±39.88 mg/L at 75.6 concentration of toxicant and 116.08±33.55 mg/L (control) to 192.62±9.24 mg/L at 75.6 concentration of toxicant.

Table 1: Activities of Haematological Parameters of *Clarias gariepinus* exposed to Potash for 21 days (Mean ± SD)

Conc. of Potash (mg/L)	WBC	RBC	HGB	PCV	MCV	MCH	MCHC	PLT
0.00	43.90 ± 41.22[a]	2.01 ± 0.75[a]	10.38 ± 1.07[a]	21.34 ± 4.14[a]	131.69 ± 4.81[b]	63.26 ± 5.27[a]	48.31 ± 5.71[a]	116.08 ± 33.55[b]
30.2	12.39 ± 8.94[b]	1.89 ± 0.56[b]	5.14 ± 3.58[b]	15.45 ± 10.34[b]	127.81 ± 13.31[b]	43.12 ± 4.30[b]	34.21 ± 3.63[b]	68.52 ± 28.38[b]
45.4	17.11 ± 5.02[b]	1.89 ± 0.15[b]	8.61 ± 0.52[a]	24.92 ± 4.63[a]	158.18 ± 19.79[a]	44.68 ± 6.02[b]	31.29 ± 2.82[b]	82.99 ± 48.27[b]
75.6	12.44 ± 3.28[b]	1.67 ± 1.14[b]	9.62 ± 1.93[a]	14.78 ± 3.62[b]	145.83 ± 39.88[a]	47.53 ± 3.94[b]	38.26 ± 7.57[b]	192.62 ± 9.24[a]

Different superscripts indicate significant difference (ANOVA + Tukey HSD, p < 0.05)

3.2 Results on Differential Count

The relative activities of differential counts of juveniles of *Clarias gariepinus* after 21 days exposure to potash are presented in Tables 2 of this study. From the results, differential counts viz; Neutrophil, Eosinophil, and Monocytes significantly fluctuated when compared with the control, viz: Neutrophil declined from 31.01±10.51% (control) to 22.49±4.05% at 75.6 concentration of toxicant; Monocytes from 4.01±4.36% (control) to 2.75±0.61% at 75.6 concentration of toxicant and Eosinophil from 15.42±8.17% (control) to 5.48±3.24% at 75.6 concentration of toxicant. Whereas, values of Lymphocytes recorded a significant (p<0.05) appreciation from 55.69±24.33% (control) to 87.34±7.54% at 75.6 concentration of the toxicant respectively.

Table 2: Activities of Differential Counts of *Clarias gariepinus* exposed to Potash for 21 days (Mean ± SD)

Conc. of Potash (mg/L)	NEU (%)	LYM (%)	MONO (%)	EOS (%)
0.00	31.01 ± 10.51[a]	55.69 ± 24.33[c]	4.01 ± 4.36[a]	15.42 ± 8.17[a]
30.2	14.35 ± 4.01[b]	86.02 ± 5.21[a]	2.36 ± 0.58[b]	4.03 ± 4.08[b]
45.4	12.01 ± 5.28[b]	88.42 ± 5.20[a]	1.38 ± 0.59[b]	3.80 ± 3.84[b]
75.6	22.49 ± 4.05[a]	87.34 ± 7.54[a]	2.75 ± 0.61[b]	5.48 ± 3.24[b]

Different superscripts within a column indicate significant difference (ANOVA + Tukey HSD, p < 0.05)

3.3 DISCUSSIONS

3.3.1 Haematological Parameters

Haematological parameters have often been associated with health indices and are of diagnostic significance in routine clinical evaluation of the state of health of fish and other animals. The results presented in Table 1 of this study indicates the haematological responses of *Clarias gariepinus* following a 21 days exposure to sublethal concentrations of potash. Some of the parameters measured include white blood cell (WBC), red blood cell (RBC), haemoglobin (HGB), pack cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin count (MCHC) and platelets (PLT).

The observed alterations in WBC, RBC, HGB, PCV, MCV, MCH, MCHC, and PLT clearly indicate that potash exerts a systemic toxic effect on blood physiology. Haematological indices are widely regarded as sensitive biomarkers in aquatic toxicology because they reflect both the physiological and pathological state of fish under environmental stress (Kanu et al., 2023; Iheanacho & Odo, 2020). The significant reduction in white blood cell (WBC) count across exposed groups suggests suppression of the immune system. Leukocytes play a central role in defense mechanisms, and their depletion often indicates reduced resistance to infection and impaired immune competence. This finding agrees with reports by Samuel and Musa (2024), who observed decreased WBC counts in Clarias gariepinus exposed to surfactants, attributing it to toxicant-induced disruption of haematopoietic tissues. In contrast, some studies have documented leukocytosis under acute exposure conditions as an adaptive response (Kanu et al., 2023). The reduction observed in the present study is therefore indicative of prolonged exposure and chronic toxicity, where the compensatory capacity of the organism may have been exceeded.

Red blood cell (RBC) count, haemoglobin concentration (HGB), and packed cell volume (PCV) showed consistent reductions in exposed groups compared to the control. These parameters are directly associated with oxygen transport and metabolic activity. Their decline is a clear indication of anaemia, which may arise from inhibited erythropoiesis, haemolysis, or osmotic imbalance induced by the toxicant. Similar reductions have been widely reported in fish exposed to pesticides and other environmental contaminants (Sayed & Mahmoud, 2014; Raimi et al., 2025). The decrease in haemoglobin concentration further suggests reduced oxygen-carrying capacity, which could impair tissue respiration and energy metabolism. This aligns with the findings of Alarape et al. (2024), who reported that toxicant exposure disrupts haem synthesis and reduces erythrocyte stability in fish.

The observed changes in packed cell volume (PCV) further support the presence of anaemic conditions. PCV reflects the proportion of blood occupied by red cells, and its reduction indicates either a decrease in erythrocyte number or cell shrinkage. This observation is consistent with earlier reports that associate toxicant exposure with haemodilution and erythrocyte destruction (Iheanacho & Odo, 2020). The combined decrease in RBC, HGB, and PCV therefore confirms that potash exposure compromises the oxygen transport system of Clarias gariepinus.

The corpuscular indices (MCV, MCH, and MCHC) provide insight into the morphological and functional status of erythrocytes. In the present study, variations in MCV suggest alterations in red blood cell size, with elevated values in some groups indicating macrocytosis. This may result from impaired erythrocyte maturation or membrane damage. Meanwhile, the reduction in MCH and MCHC observed in exposed groups indicates hypochromic conditions, where red blood cells contain less haemoglobin than normal. These findings are consistent with those of Sayed and Mahmoud (2014), who reported similar erythrocyte abnormalities in *Clarias gariepinus* exposed to carbamate pesticides. Such alterations are often linked to disruptions in iron metabolism, haem synthesis, and osmotic regulation caused by toxicants.

Platelet (PLT) counts exhibited fluctuations across treatment groups, with a notable increase at higher potash concentrations. Elevated platelet levels may reflect a physiological response to tissue injury, as platelets are involved in blood clotting and repair processes. This suggests that potash exposure may have caused internal tissue damage, triggering compensatory mechanisms. Similar responses have been reported in fish exposed to environmental pollutants, where thrombocytosis was associated with stress-induced tissue damage (Raimi et al., 2025). However, inconsistent platelet responses across concentrations indicate instability in haematological regulation under toxic stress.

The overall pattern of haematological alterations observed in this study demonstrates a concentration-dependent toxic effect of potash on Clarias gariepinus. The decline in erythrocyte parameters alongside leukocyte suppression and platelet fluctuation indicates disruption of both oxygen transport and immune function. These findings are in agreement with established toxicological studies, which have shown that chemical contaminants induce anaemia, immunosuppression, and cellular damage in fish (Kanu et al., 2023; Iheanacho & Odo, 2020).

However, some variations exist when compared with previous studies. For instance, while certain toxicants have been shown to increase WBC counts as an adaptive response, the decrease observed in this study suggests that potash may exert a more suppressive effect on the immune system. This difference may be attributed to the chemical nature of potash, exposure duration, or species-specific responses. Additionally, the observed increase in MCV in some treatment groups contrasts with studies reporting microcytic anaemia, highlighting variability in toxicant mode of action.

Haematological responses recorded in this study indicate that potash exposure induces anaemia, alters erythrocyte morphology, suppresses immune function, and disrupts haemostatic balance in *Clarias gariepinus*. The dose-dependent nature of these effects underscores the toxicological significance of potash in aquatic environments. These findings reinforce the importance of monitoring and regulating chemical inputs into aquatic systems to prevent adverse effects on fish health and ecosystem stability.

3.3.2 Differential Count

Differential count comprises the immunological parameters of white blood cells in the blood of exposed fish. Indices such as Neutrophil and Eosinophil are granulocytes also known as polymorplonuclear leucocytes (Inyang, *et al.,* 2020). In this study, differential count indices studied include Neutrophil, Lymphocyte, Eosinophil and Monocytes respectively. The results presented in Table 2 examined the toxicological effects of sub-lethal concentrations of potash on the differential leukocyte counts of *Clarias gariepinus* following a 21-day exposure period. The results revealed clear alterations in neutrophils, lymphocytes, monocytes, and eosinophils across treatment groups, indicating that potash exposure, even at sub-lethal levels, induces measurable stress responses in the fish.

Neutrophils decreased progressively with increasing potash concentration when compared with the control group. This decline suggests suppression of the innate immune system, as neutrophils are responsible for rapid defense against invading pathogens through phagocytosis. The reduction observed may be linked to toxicant-induced damage to hematopoietic organs such as the kidney and spleen. Similar reductions in neutrophil counts have been reported in Clarias gariepinus exposed to pesticides, where the effect was attributed to stress and immune suppression (Kanu et al., 2023). Adeogun et al. (2020) also reported that exposure to environmental toxicants leads to impaired leukocyte production due to oxidative stress and cellular damage.

In contrast, lymphocyte counts increased across the treated groups relative to the control. This elevation may represent a compensatory response to toxic stress, where the adaptive immune system becomes more active due to weakened innate defenses. Lymphocytosis is commonly associated with chronic exposure to pollutants and reflects immune system activation. This finding agrees with Ebeh et al. (2020), who reported increased lymphocyte counts in Clarias gariepinus exposed to fertilizer, suggesting activation of immune defense mechanisms. Similarly, Nwani et al. (2016) observed elevated lymphocyte levels in fish exposed to sub-lethal toxicants, linking the response to prolonged physiological stress.

Monocytes showed a decrease with increasing potash concentration. Since monocytes play a key role in phagocytosis and immune regulation, their reduction indicates a compromised ability of the fish to eliminate pathogens and damaged cells. This decrease may result from toxic interference with leukocyte differentiation or direct cytotoxic effects on circulating cells. Onadje et al. (2025) reported similar findings in fish exposed to cadmium, where reduced monocyte levels were associated with impaired immune competence and increased susceptibility to infections.

Eosinophils also decreased in the treated groups compared to the control, although slight variations were observed at higher concentrations. Eosinophils are involved in defense against parasites and in allergic responses. Their reduction suggests suppression of specialized immune functions, possibly due to stress-related hormonal changes or toxic effects on hematopoietic tissues. Oyeleye et al. (2020) reported similar reductions in eosinophil counts in fish exposed to environmental contaminants, linking the effect to immune imbalance and stress adaptation.

The overall pattern observed in this study indicates a shift in immune response characterized by suppression of innate immunity and activation of adaptive immunity. This imbalance may be explained by oxidative stress, a common mechanism of toxicant action in aquatic organisms. Potash exposure can alter water chemistry and ionic balance, leading to the production of reactive oxygen species, which damage blood cells and disrupt normal physiological processes. Adeogun et al. (2020) emphasized that oxidative stress is a major pathway through which toxicants affect hematological parameters in fish. In addition, potash may disrupt osmoregulatory processes by altering ion exchange across the gill membranes. This disturbance can lead to physiological stress that affects multiple organ systems, including those responsible for blood cell production. Prolonged exposure to such stress conditions can result in the hematological changes observed in this study.

When compared with recent scientific studies, the findings of this research are consistent with established patterns of hematological responses in fish exposed to sub-lethal concentrations of various toxicants. Although potash differs chemically from pesticides and heavy metals, the physiological responses observed follow a similar trend, characterized by immune suppression and compensatory adaptation. This agreement with existing literature supports the reliability of differential leukocyte counts as indicators of environmental stress in aquatic organisms. The implications of these findings are important for aquaculture and environmental management. Alterations in leukocyte profiles indicate reduced immune competence, which can increase susceptibility to disease and reduce overall fish productivity. Therefore, even low concentrations of potash in aquatic environments may pose significant risks to fish health over time.

The significance of the results obtained in Table 2 of this study reveals the potential impacts of the sub-lethal exposure of *Clarias gariepinus* to potash, significantly affecting the differential leukocyte count. The observed decrease in neutrophils, monocytes, and eosinophils, alongside increased lymphocyte counts, reflects immune imbalance and physiological stress. These findings are consistent with the research of Oyeleye et al. (2020), and highlight the potential toxicological risks of potash contamination in aquatic ecosystems. If this continues with further increase in the concentration of toxicant, the immune system of the host fish could be compromised, leading to breakdown in the immune system of exposed fish.

IV. Conclusion

The obtained results presented in Tables 1 and 2 of this study simply reveals the toxicological potentials of sublethal concentrations of potash to juveniles of *Clarias gariepinus*. Specifically, the results further reveal the impact of the toxicant on haematological indices of exposed fishes at higher concentrations. It is therefore imperative that potash and its related toxicants are potentially harmful to aquatic lives and fish in general, and should be used cautiously and in a safe manner around rivers, oceans, lakes, swamps and even flood prone environments to avoid continuous contamination and pollution of the aquatic food chain.

Going forward, regular baseline studies be carried out on the toxicity of potash to the environment, as well as engage in awareness campaigns to enlighten the public, including food vendors on the potential risks of potash, and the safety measures to be adopted with regards to its use in diets, food supplements and other industrial applications. For the purpose of reducing public health effects, fish suspected to have had accumulations of potash should not be used as source of food almost immediately, but should be allowed to stay in fresh water for a period of time before eaten. A process known as depuration.

Ethical Issues

The authors are all aware of ethical issues as stipulated by the laws of the land and thus completely complied with best practices while carrying out this research.

Competing Interest

Authors declare that there is no conflict of interest that would jeopardize the authenticity and originality of this scientific manuscript.

Authors Contribution

All authors of this research made equal contributions, ranging from data collection, analysis, manuscript proof reading and writing.

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