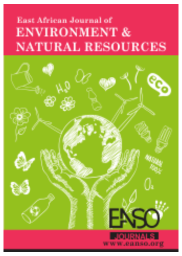


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*Original Article*

# Physico-Chemical and Entomofauna Biodiversity Assessment of Pollution Status of Taabaa Streams, Nigeria

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*Taabaa Streams, Entomofauna, Biodiversity-Indicators, Physic-Chemical Indicators, Species-Sensitivity, Dominance Indicators.*

**ABSTRACT**

Taabaa streams situated at Taabaa-Okwale and East-West roads, Taabaa were investigated using physico-chemical and entomofauna biodiversity indicators to ascertain their pollution status, following series of human activities; bathing/laundry services, cars/motorcycles washing, run-offs from agricultural farms that occur at the streams. The discharge from the run-offs and other sources into the streams may cause increase in the hydro-carbon concentration and phosphates of the water bodies and consequently changes the pH, available dissolved oxygen, and biodiversity composition of the streams, making it unsuitable for its inhabitants and humans that use the water for drinking. This study was conducted to determine the physico-chemical concentrations and entomofauna diversity of the streams. The pH quality meter was used in-situ to obtain readings of pH and dissolved oxygen values. Water samples used for the analysis of chemical variables were collected from the surface water using 250 ml plastic bottles, and taken to the Laboratory where they were measured spectrophotometrically. A rectangular frame dipnet and a kicknet (500 um mesh size) was used to collect insect samples randomly and taken to the Laboratory for sorting and identification. The results indicated a low pH, and available dissolved oxygen of 6.4 and 3.7 mg/l at the station (Taabaa-Okwale Rd) of the stream. It also shows an increase in the concentrations of phosphates (5.8 mg/l) and Total Petroleum Hydrocarbon (3.47 mg/l) which were higher than WHO permissible limits. The entomofauna indicators comprising species richness and abundance, species sensitivity, and species dominance results showed that station 1 recorded 90 and station 2 (East-West Rd) 149 individual insects. The abundance of Hemiptera and Diptera were higher at station 1 and species that belong to Ephemeroptera, Plecoptera and Trichoptera (EPT) were sensitive to the contaminants and were absent at station 1 but occurred at station 2. The bioindicator species encountered at station 1 were *Cybister* sp., *Gyrinus* sp., *Gerris* sp., *Corixa* sp., and *Chironomus* sp. and that of station 2 were in addition to EPT species; *Pelocoris* sp. and *Dytiscus* sp. Hemiptera was the dominant insect order

 

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representing 19.66% and *Chironomus* sp. the dominant single species collected during the study. The results indicates that the pollution status of station 1 was relatively higher.

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## INTRODUCTION

The aquatic ecosystem is a recipient of run-offs from agricultural farms, effluents from industries, and wastes from domestic and abattoir activities. Domestic waste run-off and garbage collection cause street and river channel pollution (Walakira & Okot-Okomu, 2011). Some fresh water bodies also serve for bathing, washing, and laundry where detergents and other chemicals such as petroleum products are washed into the ecosystem. Substances from various activities in the water bodies cause changes in the physic-chemical and biological composition of the water bodies, resulting in pollution. These substances according to Jain et al. (2010) caused undesirable change in the parameters of the ecosystem, including several adverse ecosystems impacts and ecological degradation. The undesirable change in the physic-chemical and biological characteristics of air, water, and soil that may harmfully affect the life or create potential health hazard of living organisms is what Geelani et al. (2012) defined as pollution. Several fresh water bodies in the Niger Delta region of Nigeria suffered this undesirable change and are polluted from the sources mentioned earlier. The levels of pollution in the various rivers or water bodies vary according to the concentration of the chemical, change in the level of physical parameters, and biodiversity (species composition, richness, and abundance) of living organisms. The various levels of undesirable change or pollution of a particular water body is its pollution status, which could be zero, low or high status. The pollution status of any ecosystem can be determined by measuring the impact of the contamination on the concentration of the contaminant in the ecosystem, impact on the level of the physico-chemical parameters, and the use of biological indicators to determine the impact on biological components.

Manuel and Gbarakoro (2021) reported that the pH mean values and phosphates concentration of the Isiokpo river in the Niger Delta region was relatively higher at stations characterized by bathing/laundry/fishing with nearby abattoir and waste dump than bathing/fishing stations. Dissolved oxygen concentration was lower ($4.40 \pm 0.22$) than

 

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that of bathing/fishing station (5.38 ± 0.15), and a significant difference in pH mean values, dissolved oxygen, and phosphate concentrations were recorded in their study stations. At Aleto Eleme stream, also in the Niger Delta, the concentration of dissolved oxygen that received industrial effluents was 4.4 mg/l while the Agbonchia stream which do not receive effluents was 6.5 mg/l (Gbarakoro et al., 2020). The authors further stated that the phosphate and pH values were 1.96 and 9.0 mg/l values (effluent station) and 1.0 and 7.10 mg/l (non-effluent station) respectively.

The use of physico-chemical indicators of pollution in the assessment of pollution status of the Niger Delta river was also reported at Warri River at a station close to the point of effluent discharge recorded an increase in temperature (Imobe & Okoye, 2011). Ite and Udo (2013); Beetseh and Ichakpa (2015) pointed out a decrease in pH values of freshwater body caused by a decrease in pH values of rain water run-offs containing high concentration of Carbon (IV) Oxide from gas flaring. The pH values of fresh water body have also been reported to change to alkaline due to detergents and soap-based products contained in wastewater (Davies & Day, 1998). The concentration of phosphates in Orogodo river in the Niger Delta region increased due to effluents and abattoir and refuse wastes discharged into the river which caused a reduction in dissolved oxygen concentration and saturation (Arimoro & Ikomi, 2008). The increase of phosphates in water bodies has been adduced also to increase in water conductivity caused by sewage leakages (EPA, 2016). High concentrations of phosphates in water surface are pointed out to be contributed by domestic wastewaters from detergents, industrial effluents, and fertilizer run-offs (Yisa & Jimoh, 2010). According to WHO (1998), high levels of phosphates indicate the presence of pollution and responsible for eutrophication. The severity of metal (Cd, Zn) pollution on water body is increased by lower pH (Davies et al., 2005). The mean dissolved oxygen (DO) values that ranged between 3.10-5.20 mg/l is an indication of high deoxygenated water (Yisa & Jimoh, 2010). The authors stated that the low DO, is caused by waste discharges that contain high organic matter and nutrients along increased microbial activity occurring during degradation of the organic matter (Patnaika, 2005).

The use of biotas as biological indicators of changes in an ecosystem has been described by Gatson (2000); Marques (2001) as the taxa detects the effects of natural changes caused by pollution that affect their biodiversity. Alaa et al. (2020) submitted that biotas are gifted with the ability to exhibit biotic effects of pollutants than physical or chemical investigations and thus serve as the best predictor of how ecosystems react to a stressor's invasion. Insects among biotas are highly sensitive to pollution and can be successfully employed as indicators of access and predict environmental pollution (Ali et al., 2011). Insects such as *Halobates* spp. are indicators of cadmium contamination (Schulz-Blades & Cheng, 1980), *Gerris* spp. have the potential for cadmium monitoring (Bakonyi et al., 2022) while species that belong to Corixidae and Micronecta are indicators of eutrophication in water bodies (Becker et al., 2020).

Pesticide pollution has been detected with species that belong to Corixidae and Notonectidae for imidacloprid and diazinon (Becker et al., 2020), diluted bitumen and surface washing agents detected by *Gerromorpha* species (Black et al., 2021). Manuel and Gbarakoro (2021) listed out *Chironomus* sp., *Baetis vagans*, *Cybister* sp. and *Gyrinus* sp. and *Agabus* sp. as bioindicator species of the Isiokpo river due to their presence and high abundance in contaminated ecosystem. They further stated that the contaminated station is polluted because of its low percentage of Ephemeroptera, Plecoptera, and Trichoptera (EPT) species. Fresh water insect species belonging to the three orders of EPT are used as indicators of health status (Hamid & Rawi, 2017; Savic et al., 2017).

 

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Taabaa stream is a recipient of mainly untreated sewage and domestic wastes which consist of organic substances, and other nitrogenous matter; soap and detergents from bathing/laundry services, petroleum products, oil and grease from car washes, and run-offs from agricultural farms. All these lead to increase in phosphates, pH, TPH, depletion in dissolved oxygen, and a decline in biodiversity of entomofauna which together cause a high pollution status of the river. Information on the physico-chemical and biological parameters of the river has not been provided in available literature. Worst still, the pollution status of the river is yet to be determined, still the water body is used for drinking and other services. All these necessitated the purpose of this present study in order to provide the needed information. Therefore, this study aims at determining the pollution status of Taabaa river using physico-chemical and biological indicators to ascertain its concentration of available dissolved oxygen, petroleum hydrocarbons, phosphates, and pH values, as well as its entomofauna composition, richness, and abundance.

## MATERIALS AND METHODS

### Description of Study Area

The Taabaa stream is situated in Taabaa Community of Khana Local Government Area, Rivers State, Nigeria on Latitude 4º729.36´N and Longitude 7º4142.77´E. The stream is situated on the Taabaa-okwale road, and is used for bathing/laundry, domestic purposes, and washing of motorcycles, cars. The stream was divided into two study stations; station 1 is the section located on Taabaa-okwale roadside, station 2 was located 50 meters away from station 1 with low human activities, and majorly used for drinking. Station 2 could also be accessed from Taabaa axis of East-West Road.

### Study Design

The study was designed in completely randomized design where each study station was divided into three collection points.

### Assessment of the Pollution status using Physico-Chemical Indicators

Assessment of the pollution status by the measurement of the pH level and dissolved oxygen concentration were obtained by taken readings of pH quality meter (860033 model) in-situ. The instrument was dipped into the water at the sampling points and reading taken when the meter was steady. The readings from the sampling points were averaged and recorded as the values of the parameter for each station.

Water samples used for the analysis of chemical variables; total petroleum hydrocarbon (TPH), oil and grease and phosphates were collected from the surface water into 250 ml plastic bottles and taken to the laboratory. Prior to each field trip, quality control measures were taken by washing the sampling bottles with acid according to the institute for water research glassware acid wash protocol. At the point of collection, bottles were first washed with the river water, followed by water sample collection (APHA, 1971). The bottles were filled to the neck allowing no head space and transported to the laboratory for analysis. Total phosphates, oil, and grease, and TPH concentrations were measured spectrophotometrically using standard methods (calibrated HACH3900DR spectrophotometer.

### Assessment of the Pollution status using Entomofauna Biodiversity Indicators

Insect samples were taken using a rectangular frame dipnet and a Kicknet with mesh size of 500 um wytexscreen within an approximately 25-m wadeable portion of the stream. The dimensions of the gear types are in accordance with Ogbogu (2018). The rectangular-frame net was swept over the water surface and then turned to prevent

 

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captured insects from escaping during sampling of the water surface insects. For sampling in the vegetation, the dipnet was jabbed under floating vegetation that are undisturbed, the vegetations are then shaken to dislodge organisms from it and sediments.

Samples were collected randomly from each point in a station for an average of five minutes. The samples were made into composite sample for each station, and those left in the dipnet were collected with forceps. Samples were placed in 4-Litre sample buckets and preserve with enough 70% ethanol and transported to the Entomology Research Laboratory, Department of Animal and Environmental Biology, University of Port Harcourt for sorting and identification.

Quality control measures taken in the field includes; thorough rinsing of all nets and other equipment used during sampling at a particular point or site. The equipment was examined carefully, and picked free of organisms and debris after sampling. The equipment was examined again prior to use at the next sampling site. In the laboratory, samples were washed in a 250um mesh size filter to remove debris while insects were picked with the aid of forceps.

**Data Analysis**

Concentrations of physico-chemical parameters determined in the study were compared with those of standard permissible limits for fresh water bodies and differences obtained were used to describe the pollution status of the stream and the particular parameters of stations were compared using one-way ANOVA. Pearson Correlation Coefficient was used to compare stations based on sample parameters to determine level of significance.

Entomofauna composition, abundance, and dominance of the stream were calculated to obtain the pollution status of the stream: species diversity indices (Simpson dominance (D), Shannon-weiner (H)) were employed. Percentage composition of Ephemeroptera, Plecoptera and Tricoptera (%EPT) indicators of the stream was calculated per stations; using the formula (Arimoro and Ikomi, 2009); % EPT = No. EPT species/Total No. of species calculated x 100.

**RESULTS AND DISCUSSION**

The results of the study indicate that pH values, dissolved oxygen, phosphates, and total petroleum hydrocarbon (TPH) concentrations are good indicators of pollution status of Taabaa stream (*Table 1*). The world health organization (WHO, 2014) and Federal Environmental Protection Agency of Nigeria recommended pH of 6.5-8.0 for drinking water, and 6.9-9.2 as permissible limit for fresh water and our results agree with that recommendation indicating that the station 2 water body is ideal for drinking stream water with the pH value of 9.2. The reduction in pH values for station 1 (6.4) indicates that the status of the stream is polluted as it is below the Agency's recommended value. This is corroborated with the concentration of available dissolved oxygen obtained in our study which is 3.7 (station 1) and 8.6 (station 2). In *Table 1*, station 1 is polluted as dissolved oxygen is less than 5.0 mg/l and it agrees with the submission that river with less than 5.0 mg/l is deoxygenated (Egborge, 1994; Yisa & Jimoh, 2010).

Kumar and Puri (2012) stated that life of fish and bottom dwelling invertebrates in fresh water bodies appear to be protected by a pH range of 6.0 to 9.0, and adequate DO concentration is necessary for good water quality, provided it does not exceed 13 to 14 mg/l as above that range can be harmful to aquatic life. Our findings are in support of this in two perspectives; firstly, the presence of entomofauna in both stations in our study agrees with the fact that life of aquatic species are protected at pH range of 6.4-9.2. Furthermore, the richness and abundance of species encountered at station 2, undoubtedly indicate that the water body is not relatively harmful to the species because DO is not above 13-14 mg/l. It has been reported that phosphate values of less than 5.0 mg/l which led to

 

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production of algae toxins, and concentration of total petroleum hydrocarbon of above 0.5 ppm will reduce the concentration of dissolved oxygen in fresh water body (WHO, 2011).

Our results in this study are in consonance with the report as station 1 recorded 5.8 mg/l (phosphate), and 3.47 mg/l (TPH) which are above permissible limits. This indicates that station 1 stream is polluted (*Table 1*). Station 2 that recorded below permissible limit is relatively not polluted. The reduction in dissolved oxygen caused by high concentration of phosphates and TPH is due to water run-offs from rain that deposits organic, inorganic, and debris into the river loading to degradation (Egborge, 1994), while our study agrees with that, the high concentration of TPH is caused by the washing of vehicles; cars and motor cycles at the stream-entrance, and high phosphate concentration is due to the bathing and laundry services that occur frequently in the stream with a high use of soap and detergents.

Our results on one hand agree with the report that phosphate concentration in rivers in the Niger Delta reduce dissolved oxygen (Arimoro & Ikomi, 2008) but disagree on the other hand with that of Davies and Day (1998) that detergents and soap-based products contained in wastewater changed pH values to alkaline. The high concentration of phosphates in our study is due to detergents and soap-based products from bathing, washing, and laundry which in addition to high concentration of TPH cause a reduction in pH values, unlike the case of Davies and Day (1998). Our results also show that the concentration of oil and grease is relatively high at station 1 though both stations are within the permissible limit (*Table 1*). Results of correlation coefficient reveal a correlation coefficient value of 0.332 corresponding to a p-value of 0.585, and indicates that there is no significant ($p>0.05$) correlation between stations based on sample parameters. This is added evidence that the data obtained are influenced by pollution which is more at station 1.

**Table 1: Mean Physico-chemical Indicators of the Taabaa River**

| Sample parameter | Station 1 | Station 2 | WHO permissible limit, (2011) |
|---|---|---|---|
| pH values | 6.4 | 9.2 | 6.5-9.2 |
| DO (mg/l) | 3.7 | 8.6 | Above 6.5-8 |
| $PO_4^{3-}$ (mg/l) | 5.842 | 4.972 | 5 |
| Oil and Grease (ppm) | 6.61327 | 4.41268 | 10 |
| TPH (ppm) | 3.46987 | 0 | 0.05 |

**Note**: DO-Dissolved oxygen; Po4-phosphate; TPH-Total Petroleum Hydrocarbon.

The species richness and abundance indicators of the stream show a total of nineteen species encountered during the study with a total of 251 individuals. Assessment of pollution status of the stream by abundance shows that station 1 had 90 individuals, and 161 individuals, station 2, indicating that the relatively pollution station was station 1. The high abundance of Hemipterans (47) and Dipterans (*Chironomus* sp. 18) add credence to the fact that the pollution status of the river was high at station 1.

Fresh water insects that belong to Ephemeroptera, Plecoptera, and Trichoptera according to Hamid and Rawi (2017), Savic et al. (2017) are indicators of the health status of the water body. Our study on species sensitivity indicators agree with the findings as species of the three orders were only encountered at station 2 (East-West Rd stream). Their absence at Taabaa-okwale Rd stream indicates that the water body is relatively polluted than station 2 (*Table 2*). The absence of this EPT species is due to their inability to tolerate the available concentration of dissolved oxygen which was below 5.0 mg/l at

 

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Taabaa-okwale Road stream (station 1). The EPT percentage analysis show that station 2 contain 24.3% EPT species and none for station 1.

**Table 2: Entomofauna Diversity at Taabaa River during the period of study**

| Species | Order | Station 1 | Station 2 | Total |
|---|---|---|---|---|
| Gerris sp. | Hemiptera | 13 | 0 | 67 |
| *Notonecta* sp. (Backswimmer) | | 14 | 0 | |
| *Corixa* sp. (Water boatman) | | 12 | 0 | |
| Lethocerus americanus (Giant water bug) | | 8 | 0 | |
| Pelocoris sp. | | 0 | 20 | |
| Total | | 47 | 20 | |
| Dragon nymph | Odonata | 0 | 12 | 37 |
| Damselfly | | 0 | 8 | |
| Acshma sp. | | 5 | 12 | |
| Total | | 5 | 32 | |
| Dytiscus sp. | Coleoptera | 6 | 22 | 62 |
| Cybister sp. | | 8 | 11 | |
| Gyrinus sp. | | 6 | 9 | |
| Total | | 20 | 42 | |
| Phryganea larva | Trichoptera | 0 | 8 | 26 |
| Hydropsyche larva | | 0 | 5 | |
| Leucotrichia sp. | | 0 | 7 | |
| Leptnea larva | | 0 | 6 | |
| Total | | 0 | 26 | |
| Neoptera sp. | Plecoptera | 0 | 21 | 21 |
| Total | | 0 | 21 | |
| Baetis vagans | Ephemeroptera | 0 | 8 | 14 |
| Coenis sp. | | 0 | 6 | |
| Total | | 0 | 14 | |
| *Chironomus* sp. (bloodworms) | Diptera | 18 | 6 | 24 |
| Total | | 18 | 6 | |
| Grand Total | | 90 | 161 | 251 |

The bioindicator species encountered in our study; *Cybister* sp., *Gyrinus* sp., *Gerris* sp., *Corixa* sp., and *Chironomus* sp. are those that were encountered at Isiokpo river, also in the Niger Delta region (Manuel & Gbarakoro, 2021). Their presence at station 1 indicates that they tolerate both low dissolved oxygen and high TPH and phosphates concentrations and serve as indicators of relatively high pollution status relatively high pollution status of station 1. This is attributed to the reduction in available dissolved oxygen due to the run-off discharge of hydrocarbon products, detergents, and agricultural effluents into the stream. The available concentration of dissolved oxygen is not sufficient for the entomofauna tolerance and as a result become sensitive and die away from station 1.

 

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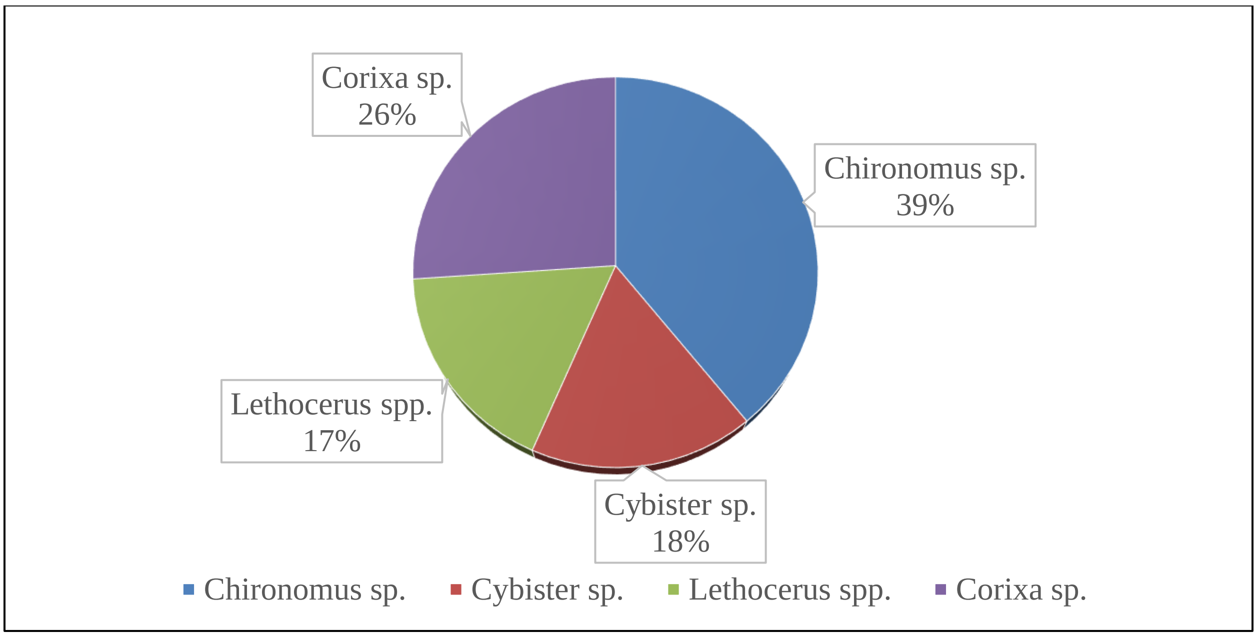
The study has pointed out some insects species which can tolerate reduced dissolved oxygen, total petroleum hydrocarbon concentrations, and high phosphates which are above permissible limits at Taabaa streams. Taabaa stream, particularly station 1 is relatively polluted and its pollution status is induced by washing/laundry services which elevated the phosphate concentration and the run-offs from washing of cars, motorcycles, and other petroleum-used engines into the water body which ultimately reduced the available dissolved oxygen, making it unsuitable for its entomofauna habitation. The extremely low level of hydrocarbon contaminant, and phosphates with a high pH values and dissolved oxygen obtained at station 2 still make the water body conducive for drinking. The relatively high abundance of species shows that it is suitable for entomofauna habitation on species dominance indicators, our results that showed that insects belonging to Hemiptera was relatively the dominant insect order among the seven orders of insects encountered in the study at the polluted stream (station 1). It recorded 47 individuals representing 19.66%, followed by coleopterans (20 individuals or 8.37… %). At the non-polluted stream (station 2), coleopterans followed by Odonata dominated by 42 individuals or 17.57% and 32 individuals or 13.39 of respectively (*Figure 1*).

**Figure 1: Insect Orders Dominant Pollution Indicators of Taabaa Stream Taabaa-okwale Rd. Station 1.**




Dominance among single species showed the following sequence in descending order of abundance; *Dytiscus* sp. (Coleoptera) > *Neoperla* sp. (Plecoptera) > *Pelocaris* sp. (Hemiptera) at station 2 (*Figure 1*) and at station 1; *Chironomus* sp. (Diptera) > *Notonecta* sp. > *Gerris* sp. (Hemiptera) (*Figure 2*). The results indicate that hemipterans are the dominant group of entomofauna indicators of polluted water body at Taabaa which tolerated low dissolved oxygen concentration, reduced pH values and high concentrations of TPH and phosphates. The relatively high abundance of three species; *Chironomus*, *Notonecta* and *Gerris*, collaborate the fact that the status of pollution of station 1 is high. Their dominance is an indication that they are bioindicators of pollution status characterized by low dissolved oxygen and concentration of TPH and phosphates above WHO permissible limits at

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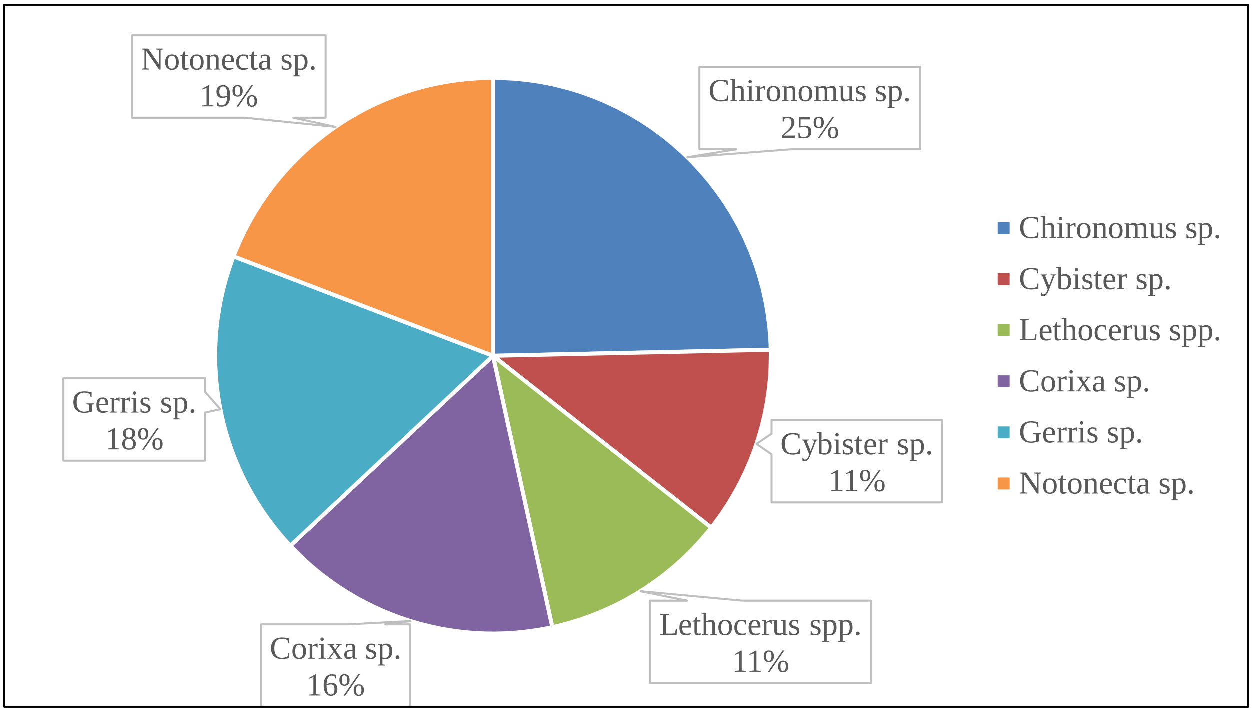
Taabaa streams. The dominance of *Dytiscus*, *Neoperla* and *Pelocoris* sp. shows that they are in addition to species of EPT indicators of clean water with efficient available dissolved oxygen circulation at Taabaa stream (station 2). The statistical analysis by Shannon-Weiner indicates that the highest number of species and individuals occurred in station 2, indicating higher species richness and diversity. The T-test statistic shows that the diversity is significantly different (p-value<0.05) between station 1 and 2. Species dominance and evenness was highest in station 1, indicating that statistically dominant tolerant species occurred more at station 1.

**Figure 2: Species Dominant Pollution Indicators of Taabaa Stream at Taabaa-okwale Rd**




## CONCLUSION

Taabaa stream located at Taabaa-okwale Road (station 1) and East-West Road (station 2) has been investigated and it shows that the pollution status of station 1 is relatively higher. The abundance of Hemiptera and Diptera were higher at station 1 and species that belong to Ephemeroptera, Plecoptera and Trichoptera (EPT) were sensitive to the contaminants and were absent at station 1 but occurred at station 2.

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