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Locational and tidal influence on nutrient dynamic and plankton cycle in Gubi dam, Bauchi state, Nigeria

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Abstract
This study investigates the locational and tidal influence on nutrient dynamic and plankton cycle of Gubi dam at three strategic locations. Station A relatively close to the source of the river (Gubi River), station B and C - spread over a distance of 450m. The experiment was designed to last for four (4) weeks. Sampling was carried out for three successive days at each station. Beside pH, total particulate matter exhibits a marked spatial difference. Physical factors were fairly homogenous. The total phytoplankton ranges from $12.0x10^2$ to $13.33x10^5$ cells/l. Phytoplankton population shows a peak abundance in station C during the first week of the study and the lowest in station A in the third week of the study. A total number of five major phytoplankton groups *Euglenophyceae, Chlorophyceae, Bacillariophyceae, Cyanophyceae, Dinophyceae, Ciliata, and Rotifera* were identified. Among the groups *Euglenophyceae* was the most abundant group contributing to about 45% of the total phytoplankton sampled. Spatial distribution of nutrients coincides to a great extend with the spatial distribution of plankton. Station C has the highest nutrient (nitrate NO^-_3) level and the greatest phytoplankton (*Euglenophyceae*) density (3.21mg/l and $13.33x10^5$ cells/l respectively). Nutrient concentration as well could be directly linked with plankton concentration. The high concentration of nutrient at all the station during the four (4) weeks of the study, suggest a tendency of high productivity at the station.

Keywords: location and tidal influence, nutrient dynamic and plankton cycle

Introduction

Plankton are the floating and drifting small animals known as (zooplankton) and plants (phytoplankton) capable of very limited locomotion, if any. Animal life of one kind or another exists at all depths of the oceans and in great abundance. Nearly half of all classes of animals are marine. Plant population is less in abundant and consists mainly of the phytoplankton and the large seaweeds and algae. Zooplanktons almost entirely dependent on the phytoplankton for its existence and these minute forms, in turn, have the same requirements for growth as other green plants. Phytoplankton constitute the primary source of food in the oceans, are restricted to a rather shallow layer of water generally no more than 450 feet (137 meters) deep called the photic zone. (Falkowski, 2002) [9]

One of the most consequential activities of phytoplankton is their influence on climate. Satellite observations and extensive oceanographic research projects are finally revealing how sensitive these organisms are to changes in global temperatures, ocean circulation, and nutrient availability (Mary and Sarah 1967) [10]. Phytoplankton draw nearly as much carbon dioxide out of the atmosphere and oceans through photosynthesis as do trees, grasses and all other land plants combined (Mary and Sarah 1967) [10]. Because phytoplankton uses almost all the energy they absorbed from the sun toward photosynthesis and reproduction, the whole marine population can replace itself every week. On the other hand, terrestrial plants must invest copious energy for growth and development, this process takes an average of twenty years to replace themselves. As phytoplankton cells divide, nearly every week on average, half the daughter cells die or are consumed by zooplankton, tiny animals that in turn provide nourishment for shrimp, fish, and bigger carnivores. Most important to climate is the organic matter that are buried in the deep ocean before it decays (Falkowski, 2002) [9].

The dynamics of rapid (or massive) increase or decrease of plankton populations is an important subject in marine plankton ecology. Generally high nutrient levels and favourable conditions play a key role in rapid or massive growth of algae and low nutrient concentration as well as unfavourable conditions limits their growth. The water must contain high levels of inorganic nutrients (nitrogen and phosphorus) for the phytoplankton to feed on and also water temperature and salinity levels must be within a certain range to be conducive to planktonic growth. A frequent outcome of planktonic bloom formation is massive cell lysis and rapid disintegration of large planktonic populations. (Chattopadhyay *et al*, 2002; Sarkar *et al*., 2007) [6, 12].

Planktons are often used as indicators of environmental and aquatic health because of their high sensitivity to changes such as eutrophication and pollution along with their short life span.

In aquaculture a great demand exists for natural live zooplankton of suitable size for feeding fish larvae as there is hardly any known species of fish that does not utilize zooplankton at one stage or the other of its life cycle. According to Abdulsalam (2007) [1], the availability of live food, especially zooplankton is an important prerequisite for successful fish hatchery operation. This is because zooplankton plays important vital role in the food web of fishes as animal food which supplies amino-acid, vitamins and mineral salt. As such their role is significant and extensively used in rearing of larvae and fry of commercially important fishes and crustaceans. Adeyemo *et al*, (1994) [2] reported the importance of these natural live zooplankton in the diet of fish larvae. Abdulsalam, (2007) [1] also demonstrated the improved performance of fish larvae fed with natural live zooplankton. Adepoju (1995) observed faster larval development and high survival rates of *Heterobranchus* and *Claris* when fed with natural live zooplankton. Successful rearing of the early stage *Heterobranchus* and *Claris* has also been achieved in National Institute for Fresh Water Fisheries Research hatchery complex (NFFR. Annual Report 1994, 1995 and 1996). Several workers in the field of fish seed production have developed various techniques for the mass culture of zooplankton using different culture media. Phytoplankton population can undergo rapid population growth or "algal blooms" when water temperature rises in the presence of excess nutrients, while increased phytoplankton population provide more food to zooplankton organism. Too much phytoplankton can harm the overall health of the environment of the organism. During these blooms, most of the phytoplankton die and sink to the bottom where they decompose. This process depletes bottom water of dissolve oxygen, which is necessary for the survival of other organism including fish and crabs. The major types of phytoplankton are green algae (Chlorophyta) Diatom (Basilliariophyta) and the blue green algae (Cyanophyta). The green algae and diatom are the best while blue green are sometimes toxic and difficult to digest because of their filamentous nature and coating of mucilage. When phytoplankton becomes full of oil, they die and sink to the bottom. They become buried under mud and sand. Over millions of years, heat and pressure within the earth transform the oil from the algae into crude-oil deposits that can later be used by humans. Gubi Dam serves as a major commercial centre for fish production, it is also the major source of water supply and provides the bulk of the fish consumed in Bauchi. The quantitative and the qualitative abundance of planktons is a very important prerequisite for fish production been that zooplanktons and phytoplanktons serves as natural food for fishes. Therefore, this study wishes to identify the spatial variation in nutrient cycle and its influence on zooplankton and phytoplankton concentration in the study area. The outcome of this study will not only lessen the expenses of fish production but also reduce the dependence of farmers on artificial fish feed.

Materials and Methods

Study Area

The Gubi reservoir is located at Firo village, Ganjuwa Local Government, about 20km from Bauchi town, Bauchi State (Anon, 2005) [5]. The reservoir which caters for the water supply and the bulk of the fish consumed in Bauchi Bauchi and its environs. The reservoir is earth-field with clay core and recharges by four converging rivers (Gora, Makaranta, Ran and Tagwaye). The Dam has a storage capacity of 38.4 x $10^6 m^3$, with a total reservoir area of about 590 hectares, a depth of 27metres, top crest width of 10metres, base width of 190metres and the total catchments area of $179 km^2$ (Anon, 2005) [5]. Figure 1.1 shows the map of the study area.

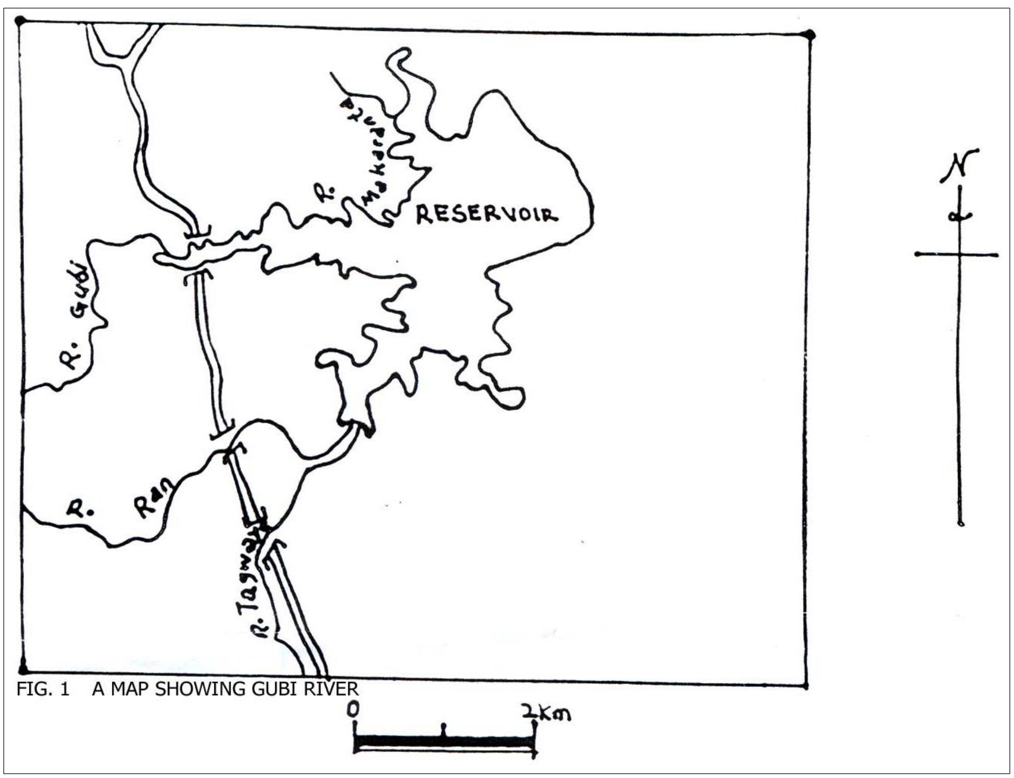


Fig 1: A Map showing the study area (Gubi River). Source: Bauchi state Ministry of land and Survey

Data collection

The study was conducted at three stations along the Gubi dam river over a distance of 450m, divided into three sampling stations. Station (a) 150m situated relatively close to the source of Gubi dam, station (b) 300m and station (c) is fairly equidistant between (a) and (b). The experiment was designed to last for four

(4) weeks. Sampling was carried out for three successive days on each week, one day at each station beginning from station (c), (b) and (a). Successive sample at a particular station were taken at regular intervals of seven (7) days.

Plankton sampling

Sampling at each station was carried out three times in a single tidal cycle (beginning of flood, mid-tide and end of flow) for plankton and two times ((beginning of flood and end of flow) for nutrient and physico-chemical parameters. For identification of phytoplankton 100 µm net was used. The samples were fixed with Lugol's iodine solution, a neutral formaldehyde was then added until a concentration of 4% was reached. The samples were allowed to settle, and the upper layer was removed by siphoning and counted in a Sedgwick–Rafter cell, using a light microscope. The results of the counting were summarized as cells per litre (Semina, 1978) [13]. The samples were observed using an inverted phase-contrast microscope.

For zooplankton isolation, a mixed culture of zooplankton was towed from Gubi dam using a zooplankton net (with mouth diameter of 10cm and mesh size of 158 µm). Several throws were made to obtain concentrated sample of zooplankton. The samples were placed in a two litres flat bottom flask and taken to the laboratory. The sample was filtered through a mosquito net to remove debris, mosquito larvae and other aquatic insects. 10 L of water was filtered through a series of plankton nets of 10, 30 and 55 µm and finally concentrated to 20 ml. The filtrates were then immediately preserved in 5% buffered formalin for further studies. Microscopic identification was performed following the standard manual. Each sample was stirred well just before microscopic examination. 1 ml of stirred sample was transferred with a wide mouth pipette. Identification and enumeration were done by a compound electrical microscope.

Measurement of physicochemical parameters

Water temperature and pH were measured using a handheld thermometer and pH meter. Total particulate matter (TPM) was determined by incineration method using oven set at 150ºC for one hour. 25ml of the water sample was placed in an oven and heated at 150^{0}C for one hour. Samples were reweighted and the lost in weight was calculated. The nutrient content of the water was analysed by adding 2ml of the water sample into a 25ml conical flask. Thereafter, 20ml of 1M ammonium acetate (77.08g/l) was added and shaken for eight (8) hours on orbital shaker. The content was filtered through a Buchner funnel. The filtrate was transferred into 50ml volumetric flask and made to volume with deionised water. NH^+_4N (Ammoniun nitrogen), NO^-_2N (Nitrate nitrogen), NO^-_3N (Nitrate nitrogen). Were determined by Atomic Absorption Spectrophotometer (AAS)

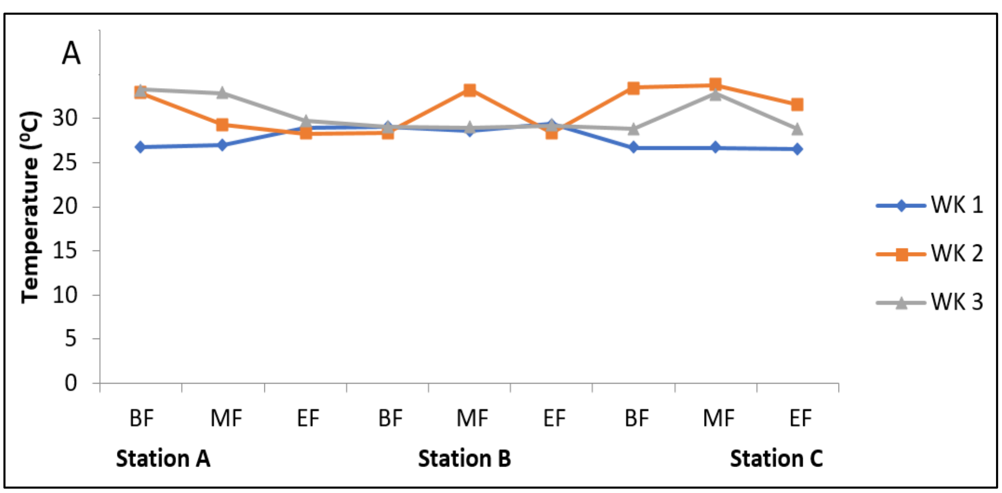
Result and Discussion

Physico-chemical parameters

In the present study, temperature ranged from 27.8ºC in the first week, 31.1ºC in the second week and 30.4ºC at the third week with an overall mean of 30ºC. Temperature remains significantly high at station C, reaching a maximum of up to 34^{0}C showing a typical seasonal pattern (Figure 2). With decreasing air temperature, surface water temperature significantly decreases at all the three stations. The temperature was slightly uniform during the first week of the study, varying from 27^{0}C at station C to 30^{0}C at station A. During the second week of the study, the temperature increases slightly up to 34^{0}C which was the maximum during the study period. The fluctuation of temperature (Figure2A) clearly shows the presence of water masses of different origin. Station C was characterized by superficial water with high temperature and low pH. Water temperature also depends on heat transfer through the sea surface, at all stations being highest at second week of the study.

During the study period the pH ranges from 6.29 to 9.95 with an overall mean of 7.4. Station B, has the highest pH (9.95). The pH was slightly uniform at station A and B with an average mean of (7.28 and 7.21 respectively). The seasonal fluctuation of pH in Gubi dam during the study period is shown in (Figure 2B). The high pH and temperature in station, B (9.95 and 33.3^{0}C respectively) may be the season for low plankton population.

Total particulate matter of the water ranges from (43 to 91mg/l) with an average mean value of 74.4mg/l. The total average particulate matter was high at station C (81mg/l), followed by station B (71mg/l) and low at station a (70 mg/l). The highest concentration of total particulate matter (TPM) occurring at station C are sufficient explanation for high temperature recorded there. Station A has the lowest total particulate matter (TPM) and correspondingly, low pH. This suggests a tendency for high productivity. The Seasonal fluctuation of total particulate matter (TPM) in Gubi dam during the study period is shown in (Figure 2C)



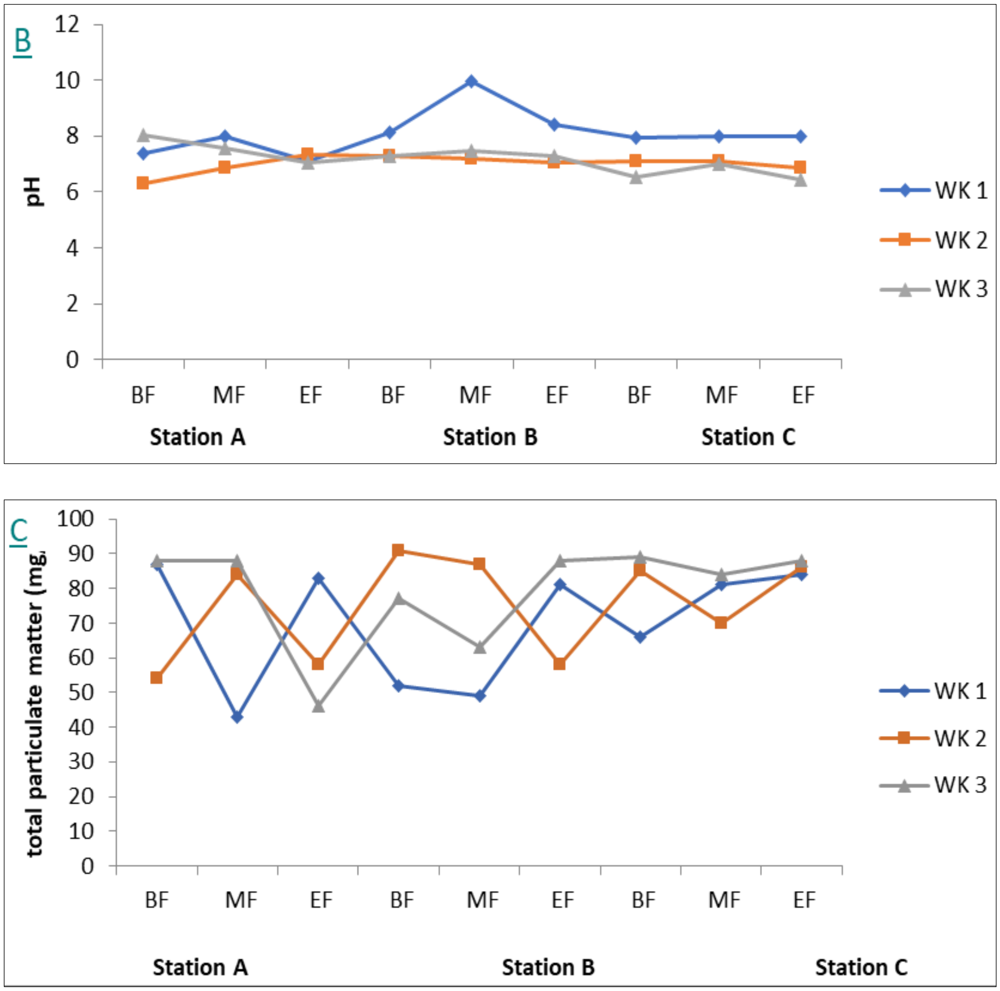
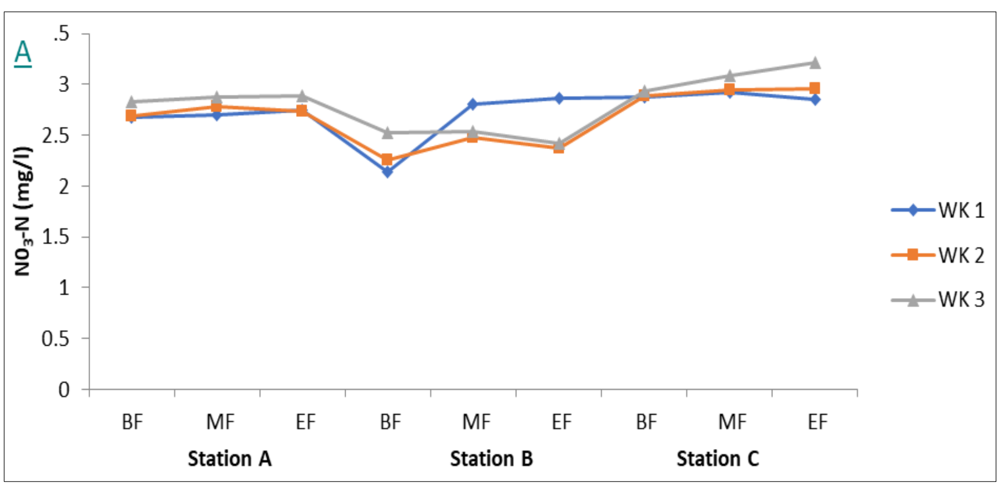


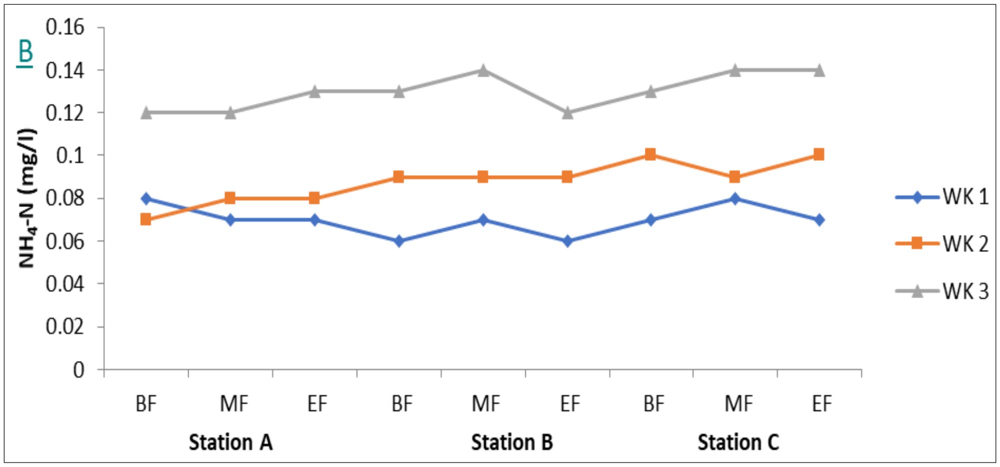
Fig 2: Shows the locational variation in physico-chemical parameters in Gubi Dam with, A) - temperature, B) - pH and, C) - total particulate matter. BF, beginning of flow, MF, middle of flow and EF, end of flow.

Nutrients

Nitrate + nitrite nitrogen [$(N0_3^- + N0_2^-)$ –N]

During the study period, Nitrate nitrogen $N0_3$-N concentration fluctuated widely from 2.14 to 3.21mg/l (mean value 2.74mg/l). The highest value was recorded in station C (1.46mg/l) and lowest in station B (1.20mg/l). During third week of sampling, ammonium nitrogen ($NH^+{}_4N$) concentration was higher at station C (0.14 mg/l), intermediate at station A and low at station B (0.13 mg/l and 0.06 mg/l respectively). (Figure 3A). The finding of this study was similar to the finding of (Chowdhury *et al*., (1970). The consisted high level of ammonia noticed in this research, is concurrent with increasing phytoplankton bloom thus suggest that the regeneration of nutrient occur at rate faster enough to mask the effect of plant utility.





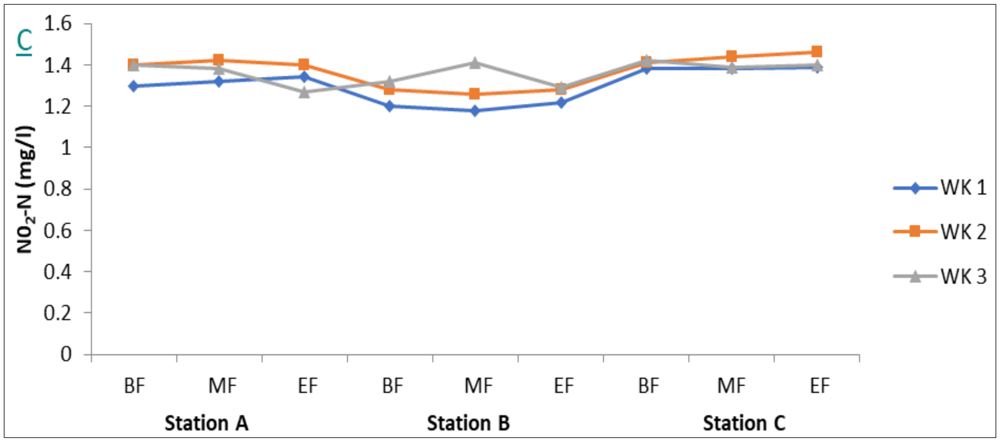


Fig 3: Shows the locational variation in nutrient content of Gubi Dam with, A) - NO_3-N, B) - NH_4-N and, C) - NO_2-N during the study period. BF, beginning of flow, MF, middle of flow and EF, end of flow.

Phytoplankton composition

Temporal abundance of phytoplankton varied from $12.0x10^3$ to $13.33x10^5$ cells/l. Phytoplankton population shows a peak abundance in station C during the first week of the study and the lowest in station A in the third week of the study. A total number of five major plankton groups: *Euglenophyceace, Chlorophyceae, Bacillariophyceae, Cyanophyceae and Dinophyceae* were identified (Table 1). Among the groups *Euglenophyceae* were the most dominant group and *Dinophyceae* is the least. The spatial distribution of nutrients coincides to a great extend with the spatial distribution of plankton. Station C has the highest nutrient level and the greatest phytoplankton density. Ehshan *et al* (2000) [8] observed that phytoplankton of inland water recorded high abundance in the month of November to December and the lowest in January. It is well established that the productivity of plankton depends on the ecological balance between the various physic-chemical factors.

Table 1: Prominent classes of phytoplankton identified in Gubi dam during the study period

Weeks	Phytoplankton (cells/l)				
	Euglenophyceae	***Chlorophyceae***	***Bacillariophyceae***	***Cyanophyceae***	***Dinophyceae***
1	$13.33x10^5$	$83.0x10^3$	$86.7x10^4$	$43.3x10^4$	$25.0x10^4$
2	$13.3x10^4$	$10.5x10^5$	$50.0x10^3$	$50.0x10^3$	$20.0x10^4$
3	$12.9x10^4$	$12.5x10^3$	$45.0x10^3$	$43.0x10^3$	$15.0x10^4$

Source: Field Survey, 2009

Euglenophyceae was the most dominant group of phytoplankton in respect to abundance with the mean value of (531666.7 cells/l) this group was the most abundant during the study period. The abundant population of *Euglenophyceae* may be as a result of exclusion. The "exclusion" hypothesis that zooplankton avoid areas rich in phytoplankton because of some toxic or unpleasant factors. *Chlorophyceae* ranked as the second highest among the phytoplankton groups in respect to abundance. The range of *chlorophyceae* numbers were from $10.5x10^5$ to $12.5x10^3$ cells/l. the occurrence of chlorophyceae was the highest in the second week of the study and least in the third week. *Bacillariophyceae* was one of the most dominant phytoplankton with ($86.7x10^4$ cells/l) and lowest in the third week with $45.0x10^3$ cells/l. *The abundance* of *Cyanophyceae* was found to be the highest in the first week with ($43.3x10^4$ cells/l) and the lowest in the third week with ($43.0x10^3$ cells/l). *Dinophyceae* was the least dominant group of phytoplankton in respect to both abundance and number species. *Dinophyceae* was the most abundance in the first week ($25.0x10^4$ cells/l) this group was rarely found in the third week of the study (Table 1).

Zooplankton population

The zooplankton population of Gubi Dam are composed of two major groups: *Ciliata* and *Rotifera* Total zooplankton population ranges from (50.0x104 to 3.92x103 cells/l). Weekly variation in mean population of *Ciliate* and *Rotifera* in Gubi Dam are shown in (Figure 4.).

In the present study, the highest phytoplankton density and species diversity was found when the temperature and $N0_3$-N concentration were found to be highest. Similar relationship also was also present in case of lower abundance of phytoplankton in low temperature and N-$N0_3$ concentration. The range of total zooplankton population was from ($50.0x10^4$ to $3.92x10^3$cells/l) with mean value of ($236.22x10^3$ cells/l) which was more or less close to the value reported by Razzaque *et al* (1995) [11]. In another study, Ahmed *et al* (2004) [3] reported that *Crustacea* was dominant group and *Rotifera* was the rarest among zooplankton the population in Shakla beel.

There is substantial evidence that zooplankton contributes significantly to the regeneration of nutrients.

Ajah, (2002) [4] showed that ammonia and phosphate excreted by zooplankton met 40-90% of the nitrogen and 52-140% of phosphate demand of phytoplankton in various marine environments.

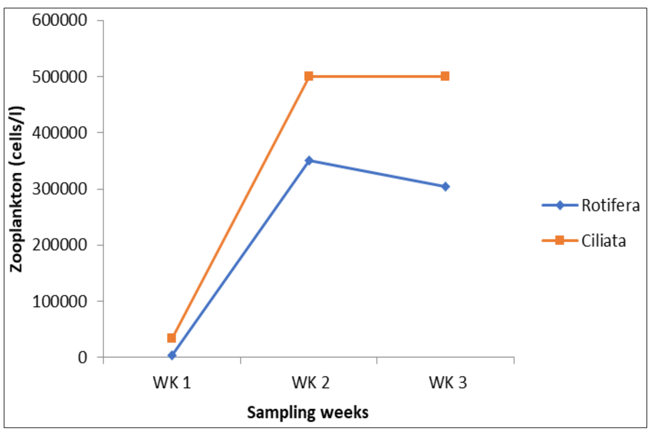


Fig 4: Weekly variation in the mean abundance of *Ciliata* and *Rotifera* in Gubi dam during the study period

The result of the showed an inverse relationship between phytoplankton and zooplankton densities with sharp increase in phytoplankton numbers coinciding with a sudden drop in zooplankton count indicating the importance of the level of nutrients for plankton growth. The reduced density of phytoplankton is concurrent with an increase in zooplankton density suggest grazing by herbivours zooplankton. The effects of zooplankton grazing were obvious at the third week as the class composition of phytoplankton seem to decrease. The grazing effect becomes more evident at the first week when class composition of phytoplankton decreased while that of zooplankton increased.

Conclusion

The Gubi Dam River exhibit an appreciable degree of spatial and tidal physical homogeneity, with spatial variation in nutrient and plankton cycles. In the present study, the highest phytoplankton density and species diversity was found when the temperature and $N0_3$-N concentration were found to be highest. Inversely, lower abundance of phytoplankton was recorded in low temperature and N-$N0_3$ concentration. The range of total zooplankton population was from ($50.0x10^4$ to $3.92x10^3$cells/l) with mean value of ($236.22x10^3$ cells/l).

The area with the high concentration of nutrients (station C) has the highest population of phytoplankton particularly *Euglenophyceae* and *Chlorophyceae.* The abundant population of *Euglenophyceae* may be as a result of exclusion. The "exclusion" hypothesis states that zooplankton avoid areas rich in phytoplankton because of some toxic or unpleasant factors. Nutrient composition as well could be directly linked with plankton composition, as observed from the research. The prominent high concentration of phytoplankton as well as general increase in nutrient corresponds with high productivity. It can therefore be concluded that the nutrients level at Gubi dam is high, consequently the zooplankton is also high this signifies high productivity and a good site for fish farming.

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