# NITRATE, PHOSPHATE AND POTASSIUM POLLUTION INDICES IN WATER OF SUKA STREAM, MINNA, NIGER STATE.

BY

*J.O MAJI, M.A.T. SULEIMAN, P.A.E. AKO AND S.0. SALIHU

CHEMISTRY DEPARTMENT, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

*Corresponding Author

*(email: rosiema70@yahoo.com)

**ABSTRACT**

Nitrate, phosphate ad potassium content of Suka stream in Minna, Niger State were determined to ascertain the level of pollution with respect to these ions. Water samples were taken from thirteen different points along the stream weekly from a period spanning the dry and wet seasons of the year. Nitrate was determined by UV-Visible spectrophotometric method, phosphate by Perchloric acid method, while potassium content was estimated by the Atomic Absorption Spectrophotometry. Levels of the three ions were generally higher during the wet season. Nitrate content ranged from 8-40mg/L while phosphate and potassium contents were 0.20-3.58mg/L and 1.6-5.9mg/L respectively. These values are compared with the permissible limits of World Health organization (WHO) and the Federal Environmental Protection Agency (FEPA) of Nigeria.

**INTRODUCTION**

Water, although occupies the second place of importance for the existence and sustenance of life after air, is perhaps, the most sought after social amenity. This stems from the wide range of uses to which it is being put. However, because of its inherent good solvent property, water is hardly found in a pure state so that its acceptability depends on the purpose for which it is needed (Botkin and Keller, 1998; Cunningham an Saigo, 1999).Therefore, it is not surprising that the type of analysis to which water is subjected is also very often not unrelated to the problem that it is meant to solve. Expectedly too, standards for water are set according to whether it is for its potability, agricultural use, recreational suitability, or other specified use (Botkin and Keller, 1998).

Without doubt, water will continue to be in great demand by man who must need it for his daily domestic, economic and /or social activities. But it is of great importance where the water is sourced. Natural sources, such as streams, rivers and ponds (surface waters) are highly subject to contamination or pollution, due to their exposure to different forms of human and other interactions. As a consequence of the diversity of these interactions, the parameters that are determined in water are specific to the suspected nature of the pollution and the purpose to which the water is to be applied.

Suka stream derives its source from the hills north of Bosso village on the outskirts of Minna metropolis and meanders in a north-western direction through Dutsen Kura to Kpakungu, both within Minna, from where it cuts through farmlands to join the Chanchaga River. Along the stream are developed and undeveloped plots of land that are either meant for residential, commercial or agricultural use. Thus, the stream receives a wide range of pollutants whose sources include household or domestic waste, sewage (septic systems), automobile and agrochemicals. The water from the stream serves mainly for washing and irrigati purposes, but children and even adults, especially farmers are seen bathing in it. It is also a source c drinking water for the latter and herdsmen who may find it sufficiently "clean" to quench their thirst while engaged in their farm work. This called for the need to assess the suitability of the Suka stream water for domestic use, with regard to its potassium, phosphorus and nitrate content.

**MATERIALS AND METHODS**

The water samples used for this analysis were taken from thirteen different points along the course of the Suka stream. The samples were collected weekly from July 2000 to February 2001, a period which cut across the rainy and early part of the dry seasons. Sampling was done using 2L capacity plastic bottles, which were previously treated with 10% v/v nitric acid solution (by soaking them overnight) and then rinsed thoroughly with de-ionized distilled water. The bottles were further rinsed twice with the sample at the point of sampling before sample collection and then corked. To ensure a more adequate representation of the sampling sites, samples were taken from the top as well as 1m dept below the water surface on non-rainy days and during the dry season, and immediately after the rainfall, during the wet season.

Total phosphate was determined in two steps: first by the conversion of the naturally occurring phosphorus form ($H_2PO_4^-$, $HPO_4^{2-}$ or $PO_4^{3-}$) to soluble orthophosphate using the perchloric acid digestion method and secondly by colorimetric determination of the soluble orthophosphate using the vanadomolybdenum-phosphoric acid colorimetric methods (Ademoroti, 1996) by means of a Camspec uv/visible spectrophotometer model M302/202. Nitrate was measured using spectrophotometric method (Pye Unicam, 1995) on Camspec spectrophotometer (model M302/202, uv/visible). Potassium, on the other hand, was estimated by atomic absorption spectrophotometry (AAS) using an Atomic Absorption Spetrophotometer (Philip Model PU 9100)

## RESULTS AND DISCUSSION.

The focus on the levels of potassium, phosphate and nitrate in this study was informed by the knowledge of the nature of possible pollutants. Contributions from sewage tanks and runoff from agricultural land were the major targets. Niger state is an agrarian state. Agrochemicals, especially fertilizers, including farmyard manures and commercial fertilizers, are intensively used to improve the fertility of the soils of the farmlands, most of which are under continuous cultivation.

The minimum and maximum levels of potassium, phosphorus and nitrate are presented in Table 1. T determined maximum level of 3.58 mg/l phosphate is higher than the threshold limit of 0.1 mg/l recommended by the United States Environmental Protection Agency (USEPA), but below Nigeria's FEPA effluent limit of 5.0 mg/l. Incidentally the same sample gave the maximum nitrate level of 40 mg/l, which falls below the permissible limit of 45 mg/l recommended by the World Health Organisation (WHO).

The presence of phosphorus or nitrate in the water indicates sewage effluent input. Phosphorus compounds are present in waters only in minor concentrations, but can influence substantially the growth of aquatic plants, especially algal bloom (Hellmann, 1987; Nikoladze *et al*, 1989). Water containing levels of nitrate higher than 45 mg/l has been reported to cause methaemoglobineamia in infants (Caincross and Feachem, 1983; WHO, 1958). Indisputably, Suka stream is unsuitable as a source of drinking water, in spite of the observation made earlier in this report (Enejoh, 2002). Although there are no published WHO standards for potassium to enable a comparative statement on the level of this element in the water under investigation in this report, it is known, like sodium, to play a very important role in nervous communication. Its concentration in most drinking water is about 20 mg/l (APHA, 1989).

In Table 2, seasonal mean concentrations of the three ions in the stream are presented. The dry season levels were generally lower compared to those of the wet season. This is, perhaps, an indication that during the dr season, contribution to the pollutants pool from domestic wastes and runoff from septic systems a agricultural activities decreased. This may be attributable to one or more factors, one of which is the probable reduction in the volume of wastewater generated from the nearby homes. This thinking may be valid, considering the familiar incidence of water shortage in Minna metropolis during the dry season of every year, resulting from low levels of water in the two dams that supply the water treatment plants in Bosso and Chachanga. A second factor is, probably, the increased rate of evaporation which prevents wastewater from the source reaching the stream. A combination of these two factors is also a possibility.

It is arguable that lower levels of the ions should occur during the wet season, since higher volumes of water should have a diluting effect on the concentration of ions in the stream. That this was not the case, therefore, seems to suggest that the pollutant load carried into the stream by runoff during the dry season greatly outstripped the expected dilution effect.

A third possible reason for the observed trend is provided by the high density of plant growth in the slow-running or stagnant water of the stream during the dry season. The plants draw part of their nutrient from the water directly and indirectly for their metabolism, thereby depleting the concentration of the ion concerned.

Figure 1 shows clearly that pollutant load increased with increase in the intensity and frequency of the rains. A peak value of pollutants concentration was attained in the month of August which corresponded to t period when the rains were heaviest. A steady decrease in the levels of the ions then followed a decline in the intensity of the rains until the dry month of January when the last sampling was carried out.

## CONCLUSION AND RECOMMENDATION.

In concluding this report, it is pertinent to draw attention to the fact that the Bosso water treatment plant draws its supply from a dam constructed across the Suka stream. Fortunately, the dam is located at the upper end of the stream where the human population density and domestic activities are relatively low. Nonetheless, agricultural activities are high and the area is witnessing increased rate of development. Therefore, pollutant receiving points for the stream are more likely to increase than decrease.

An earlier report (Enejoh *et al*, 2002), had observed that the quality of water supplied from the Bosso treatment plant decreased during the raining seasons. The present report lends credence to that observation and calls for greater strategies and material input by the Niger state Water and Sanitation Board to ensure that good quality potable water reaches the homes of Bosso village residents.

**TABLE 1: OVERALL MAXIMUM AND MINIMUM VALUES OF THE PARAMETERS DETERMINED**

| Parameters/sample numbers | PHOSPHATE | | NITRATE | | POTASSIUM | |
|---|---|---|---|---|---|---|
| | MAX | MIN | MAX | MIN | MAX | MIN |
| 1 | 1.51 | 0.25 | 29 | 10 | 5.40 | 2.21 |
| 2 | 1.53 | 0.26 | 25 | 8 | 5.30 | 2.00 |
| 3 | 3.48 | 0.21 | 39 | 15 | 5.90 | 2.21 |
| 4 | 3.46 | 0.23 | 32 | 15 | 5.50 | 2.30 |
| 5 | 2.43 | 0.22 | 26 | 10 | 4.50 | 1.69 |
| 6 | 2.45 | 1.22 | 30 | 10 | 4.00 | 2.40 |
| 7 | 1.50 | 0.24 | 31 | 18 | 4.20 | 2.30 |
| 8 | 3.58 | 2.30 | 40 | 30 | 5.80 | 3.20 |
| 9 | 3.48 | 2.30 | 39 | 31 | 5.90 | 3.40 |
| 10 | 3.40 | 1.24 | 39 | 24 | 5.41 | 2.90 |
| 11 | 2.39 | 0.26 | 39 | 25 | 5.50 | 2.80 |
| 12 | 1.39 | 0.22 | 38 | 24 | 5.52 | 3.00 |
| 13 | 1.29 | 0.20 | 19 | 8 | 3.74 | 1.60 |

**TABLE 1.0: MONTHLY MEAN VALUES OF PHOSPHATE, POTASSIUM AND NITRATE CONCENTRATIONS (MG/L)**

| MONTHS | PHOSPHATE | POTASSIUM | NITRATE |
|---|---|---|---|
| July, 2000 | 0.86 | 2.87 | 19 |
| August, 2000 | 2.14 | 4.12 | 28 |
| September, 2000 | 1.62 | 4.57 | 28 |
| October, 2000 | 1.57 | 4.61 | 26 |
| November, 2000 | 1.40 | 3.73 | 16 |
| December, 2000 | 1.16 | 3.06 | 15 |
| January, 2001 | 1.04 | 2.07 | 14 |
| February, 2001 | 1.03 | 2.0 | 13 |

## CONCLUSION AND RECOMMENDATION.

In concluding this report, it is pertinent to draw attention to the fact that the Bosso water treatment plant draws its supply from a dam constructed across the Suka stream. Fortunately, the dam is located at the upper end of the stream where the human population density and domestic activities are relatively low. Nonetheless, agricultural activities are high and the area is witnessing increased rate of development. Therefore, pollutant receiving points for the stream are more likely to increase than decrease.

An earlier report (Enejoh *et al*, 2002), had observed that the quality of water supplied from the Bosso treatment plant decreased during the raining seasons. The present report lends credence to that observatio and calls for greater strategies and material input by the Niger state Water and Sanitation Board to ensure that good quality potable water reaches the homes of Bosso village residents.

**TABLE 1: OVERALL MAXIMUM AND MINIMUM VALUES OF THE PARAMETERS DETERMINED**

| Parameters/sample numbers | PHOSPHATE | | NITRATE | | POTASSIUM | |
|---|---|---|---|---|---|---|
| | MAX | MIN | MAX | MIN | MAX | MIN |
| 1 | 1.51 | 0.25 | 29 | 10 | 5.40 | 2.21 |
| 2 | 1.53 | 0.26 | 25 | 8 | 5.30 | 2.00 |
| 3 | 3.48 | 0.21 | 39 | 15 | 5.90 | 2.21 |
| 4 | 3.46 | 0.23 | 32 | 15 | 5.50 | 2.30 |
| 5 | 2.43 | 0.22 | 26 | 10 | 4.50 | 1.69 |
| 6 | 2.45 | 1.22 | 30 | 10 | 4.00 | 2.40 |
| 7 | 1.50 | 0.24 | 31 | 18 | 4.20 | 2.30 |
| 8 | 3.58 | 2.30 | 40 | 30 | 5.80 | 3.20 |
| 9 | 3.48 | 2.30 | 39 | 31 | 5.90 | 3.40 |
| 10 | 3.40 | 1.24 | 39 | 24 | 5.41 | 2.90 |
| 11 | 2.39 | 0.26 | 39 | 25 | 5.50 | 2.80 |
| 12 | 1.39 | 0.22 | 38 | 24 | 5.52 | 3.00 |
| 13 | 1.29 | 0.20 | 19 | 8 | 3.74 | 1.60 |

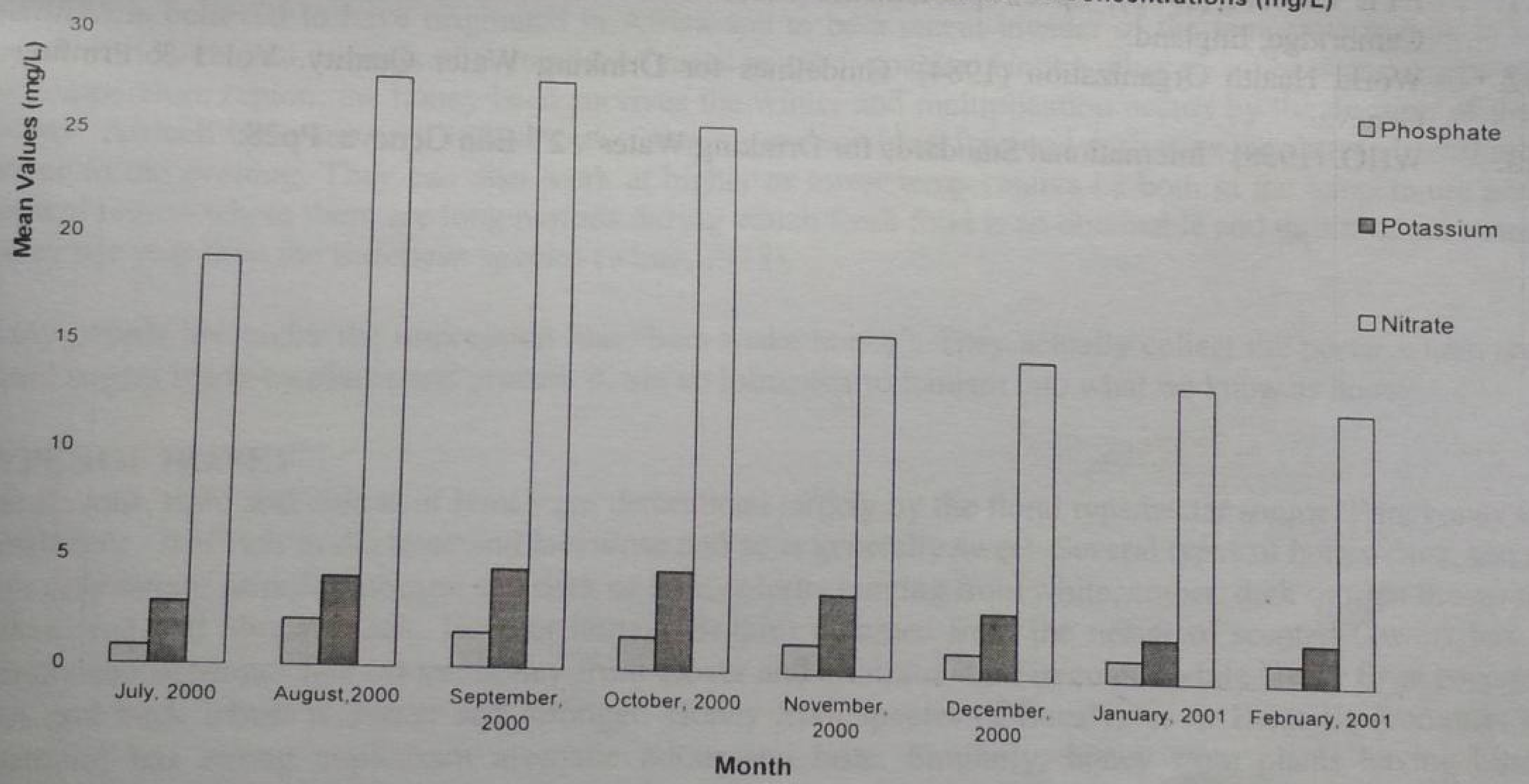
**TABLE 1.0: MONTHLY MEAN VALUES OF PHOSPHATE, POTASSIUM AND NITRAT CONCENTRATIONS (MG/L)**

| MONTHS | PHOSPHATE | POTASSIUM | NITRATE |
|---|---|---|---|
| July, 2000 | 0.86 | 2.87 | 19 |
| August, 2000 | 2.14 | 4.12 | 28 |
| September, 2000 | 1.62 | 4.57 | 28 |
| October, 2000 | 1.57 | 4.61 | 26 |
| November, 2000 | 1.40 | 3.73 | 16 |
| December, 2000 | 1.16 | 3.06 | 15 |
| January, 2001 | 1.04 | 2.07 | 14 |
| February, 2001 | 1.03 | 2.0 | 13 |

**TABLE 2.0: SEASONAL MEAN VALUES OF NITRATE, PHOSPHATE & POTASSIUM CONTENTS**

| SAMPLE NUMBERS | PARAMETERS (mg/L) | | | | | |
|---|---|---|---|---|---|---|
| | NITRATE | | PHOSPHATE | | POTTASSIUM | |
| | DRY | WET | DRY | WET | DRY | WET |
| 1 | 10.0 | 24.83 | 1.27 | 1.43 | 2.9 | 4.2 |
| 2 | 9.0 | 22.00 | 1.26 | 1.42 | 2.8 | 4.2 |
| 3 | 10.0 | 31.08 | 1.27 | 2.63 | 2.9 | 4.4 |
| 4 | 17.5 | 27.80 | 2.31 | 3.36 | 3.0 | 4.3 |
| 5 | 12.0 | 21.30 | 1.28 | 1.36 | 2.3 | 3.0 |
| 6 | 12.0 | 27.20 | 1.29 | 1.66 | 2.7 | 3.4 |
| 7 | 18.0 | 26.00 | 1.34 | 1.39 | 2.8 | 3.5 |
| 8 | 28.4 | 36.10 | 1.52 | 3.53 | 4.2 | 5.1 |
| 9 | 27.8 | 36.00 | 1.38 | 3.48 | 3.8 | 5.0 |
| 10 | 26.0 | 33.00 | 1.28 | 2.64 | 3.5 | 4.7 |
| 11 | 26.5 | 34.20 | 1.28 | 1.7 | 3.5 | 4.8 |
| 12 | 25.5 | 33.90 | 1.25 | 1.32 | 3.9 | 4.7 |
| 13 | 9.0 | 12.60 | 0.26 | 0.70 | 2.0 | 3.1 |
| 14 | 0.2 | 0.07 | 0.00 | 0.01 | 4.1 | 3.92 |

**Fig. 1.0: Monthly Mean Values of Phosphate, Potassium and Nitrate Concentrations (mg/L)**



**REFERENCES**

1. Ademoroti C.M.A. (1996): Standard Method for Water Effluents Analysis. Foludex Press Ltd, Ibadan, Nigeria. (pg 22-101)
2. American Public Health Association (APHA) (1975): "Standard Methods for the Examination of Water and Waste Water, 14th Edition APHA Office, Washington, p 234
3. Botkin, D.B. and Keller, E.A. (1998). Environmental Science. Earth as a Living Planet. 2nd Edn. John Wiley and Sons Inc, New York pp414-438.
4. Caincross, S. and Feachem, R.G. (1983). Environmental Health Engineering in the Tropics: An Introductory Text. John Wiley and Sons Ltd. New York pp. 26.
5. Cunningham, W.P. and Saigo, B.W. (1999). Environmental Science. A Global Concern. Mcgraw-Hill inc. New York, pp. 435-460
6. Enejoh J.O., Ako, P.A.E. and Lawani, S.A. (2002). Wet Season Water Quality in Minna Metropolis and Environs. Conference Proceedings. National Association of Teachers of Technology, 15th Annual Conference. Pp315-319.
7. Enejoh J.O (2002): Environmental Water Pollution: Some Pollutant Indices in River Suka, Minna, Niger State. Unpublished M. Tech. Thesis, FUT Minna.
8. Federal Environmental Protection Agency (FEPA 1991): Guidelines and Standard for Environmental Pollution Control in Nigeria.
9. Hellman H. (1987): "Analysis of Surface Water". Ellis Horwood Ltd. Chichester, England. Pg. 11-23
10. Nikoladze G., Mints D and Kastalsky, A; (1989) "Water Treatment for Public and Industrial Supply, MIR Publishers, pp 12-17.
11. PYE Unicam (1995); Spectrophotometric Method Sheet (x4) Published by PYE Unicam Ltd., Cambridge, England.
12. World Health Organization (1984): Guidelines for Drinking Water Quality. Vol 1-3. Printing , Geneva.
13. WHO. (1958) "International Standards for Drinking Water". 2nd Edn Geneva. Pp28.

ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

Total phosphate was determined in two steps: first by the conversion of the naturally occurring phosphorus form ($H_2PO_4^-$, $HPO_4^{2-}$ or $PO_4^{3-}$) to soluble orthophosphate using the perchloric acid digestion method and secondly by colorimetric determination of the soluble orthophosphate using the vanadomolybdenum-phosphoric acid colorimetric methods (Ademoroti, 1996) by means of a Camspec uv/visible spectrophotometer model M302/202. Nitrate was measured using spectrophotometric method (Pye Unicam, 1995) on Camspec spectrophotometer (model M302/202, uv/visible). Potassium, on the other hand, was estimated by atomic absorption spectrophotometry (AAS) using an Atomic Absorption Spetrophotometer (Philip Model PU 9100)

## RESULTS AND DISCUSSION.

The focus on the levels of potassium, phosphate and nitrate in this study was informed by the knowledge of the nature of possible pollutants. Contributions from sewage tanks and runoff from agricultural land were the major targets. Niger state is an agrarian state. Agrochemicals, especially fertilizers, including farmyard manures and commercial fertilizers, are intensively used to improve the fertility of the soils of the farmlands, most of which are under continuous cultivation.

The minimum and maximum levels of potassium, phosphorus and nitrate are presented in Table 1. T determined maximum level of 3.58 mg/l phosphate is higher than the threshold limit of 0.1 mg/l recommended by the United States Environmental Protection Agency (USEPA), but below Nigeria's FEPA effluent limit of 5.0 mg/l. Incidentally the same sample gave the maximum nitrate level of 40 mg/l, which falls below the permissible limit of 45 mg/l recommended by the World Health Organisation (WHO).

The presence of phosphorus or nitrate in the water indicates sewage effluent input. Phosphorus compounds are present in waters only in minor concentrations, but can influence substantially the growth of aquatic plants, especially algal bloom (Hellmann, 1987; Nikoladze *et al*, 1989). Water containing levels of nitrate higher than 45 mg/l has been reported to cause methaemoglobineamia in infants (Caincross and Feachem, 1983; WHO, 1958). Indisputably, Suka stream is unsuitable as a source of drinking water, in spite of the observation made earlier in this report (Enejoh, 2002). Although there are no published WHO standards for potassium to enable a comparative statement on the level of this element in the water under investigation in this report, it is known, like sodium, to play a very important role in nervous communication. Its concentration in most drinking water is about 20 mg/l (APHA, 1989).

In Table 2, seasonal mean concentrations of the three ions in the stream are presented. The dry season levels were generally lower compared to those of the wet season. This is, perhaps, an indication that during the d season, contribution to the pollutants pool from domestic wastes and runoff from septic systems a agricultural activities decreased. This may be attributable to one or more factors, one of which is the probable reduction in the volume of wastewater generated from the nearby homes. This thinking may be valid, considering the familiar incidence of water shortage in Minna metropolis during the dry season of every year, resulting from low levels of water in the two dams that supply the water treatment plants in Bosso and Chachanga. A second factor is, probably, the increased rate of evaporation which prevents wastewater from the source reaching the stream. A combination of these two factors is also a possibility.

It is arguable that lower levels of the ions should occur during the wet season, since higher volumes of water should have a diluting effect on the concentration of ions in the stream. That this was not the case, therefore, seems to suggest that the pollutant load carried into the stream by runoff during the dry season greatly outstripped the expected dilution effect.

A third possible reason for the observed trend is provided by the high density of plant growth in the slow-running or stagnant water of the stream during the dry season. The plants draw part of their nutrient from the water directly and indirectly for their metabolism, thereby depleting the concentration of the ion concerned.

Figure 1 shows clearly that pollutant load increased with increase in the intensity and frequency of the rain A peak value of pollutants concentration was attained in the month of August which corresponded to t period when the rains were heaviest. A steady decrease in the levels of the ions then followed a decline in the intensity of the rains until the dry month of January when the last sampling was carried out.

## CONCLUSION AND RECOMMENDATION.

In concluding this report, it is pertinent to draw attention to the fact that the Bosso water treatment plant draws its supply from a dam constructed across the Suka stream. Fortunately, the dam is located at the upper end of the stream where the human population density and domestic activities are relatively low. Nonetheless, agricultural activities are high and the area is witnessing increased rate of development. Therefore, pollutant receiving points for the stream are more likely to increase than decrease.

An earlier report (Enejoh *et al*, 2002), had observed that the quality of water supplied from the Bosso treatment plant decreased during the raining seasons. The present report lends credence to that observation and calls for greater strategies and material input by the Niger state Water and Sanitation Board to ensure that good quality potable water reaches the homes of Bosso village residents.

**TABLE 1: OVERALL MAXIMUM AND MINIMUM VALUES OF THE PARAMETERS DETERMINED**

| Parameters/sample numbers | PHOSPHATE | | NITRATE | | POTASSIUM | |
|---|---|---|---|---|---|---|
| | MAX | MIN | MAX | MIN | MAX | MIN |
| 1 | 1.51 | 0.25 | 29 | 10 | 5.40 | 2.21 |
| 2 | 1.53 | 0.26 | 25 | 8 | 5.30 | 2.00 |
| 3 | 3.48 | 0.21 | 39 | 15 | 5.90 | 2.21 |
| 4 | 3.46 | 0.23 | 32 | 15 | 5.50 | 2.30 |
| 5 | 2.43 | 0.22 | 26 | 10 | 4.50 | 1.69 |
| 6 | 2.45 | 1.22 | 30 | 10 | 4.00 | 2.40 |
| 7 | 1.50 | 0.24 | 31 | 18 | 4.20 | 2.30 |
| 8 | 3.58 | 2.30 | 40 | 30 | 5.80 | 3.20 |
| 9 | 3.48 | 2.30 | 39 | 31 | 5.90 | 3.40 |
| 10 | 3.40 | 1.24 | 39 | 24 | 5.41 | 2.90 |
| 11 | 2.39 | 0.26 | 39 | 25 | 5.50 | 2.80 |
| 12 | 1.39 | 0.22 | 38 | 24 | 5.52 | 3.00 |
| 13 | 1.29 | 0.20 | 19 | 8 | 3.74 | 1.60 |

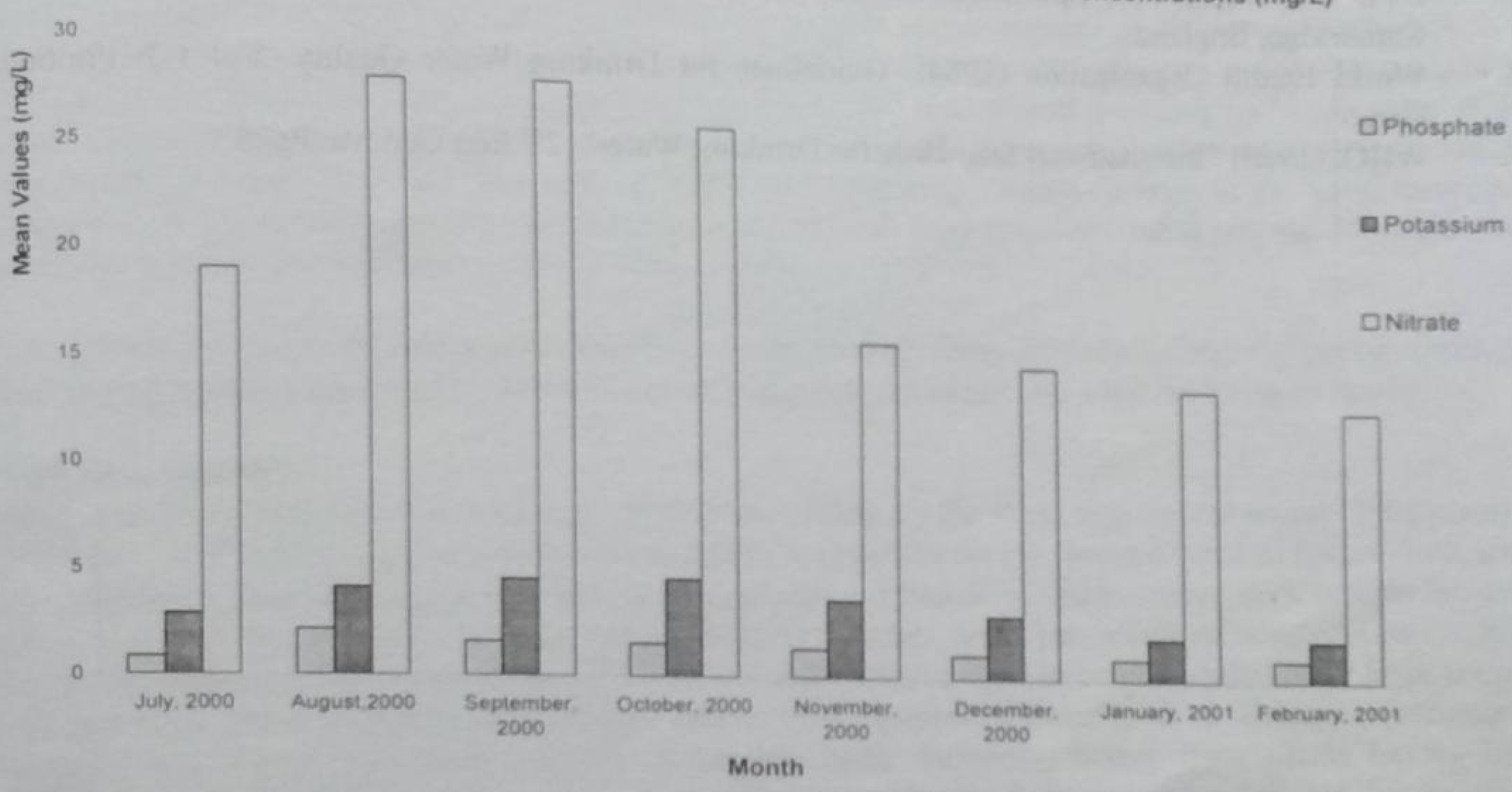
**TABLE 1.0: MONTHLY MEAN VALUES OF PHOSPHATE, POTASSIUM AND NITRATE CONCENTRATIONS (MG/L)**

| MONTHS | PHOSPHATE | POTASSIUM | NITRATE |
|---|---|---|---|
| July, 2000 | 0.86 | 2.87 | 19 |
| August, 2000 | 2.14 | 4.12 | 28 |
| September, 2000 | 1.62 | 4.57 | 28 |
| October, 2000 | 1.57 | 4.61 | 26 |
| November, 2000 | 1.40 | 3.73 | 16 |
| December, 2000 | 1.16 | 3.06 | 15 |
| January, 2001 | 1.04 | 2.07 | 14 |
| February, 2001 | 1.03 | 2.0 | 13 |

**TABLE 2.0: SEASONAL MEAN VALUES OF NITRATE, PHOSPHATE & POTASSIUM CONTENTS**

| SAMPLE NUMBERS | PARAMETERS (mg/L) | | | | | |
|---|---|---|---|---|---|---|
| | NITRATE | | PHOSPHATE | | POTTASSIUM | |
| | DRY | WET | DRY | WET | DRY | WET |
| 1 | 10.0 | 24.83 | 1.27 | 1.43 | 2.9 | 4.2 |
| 2 | 9.0 | 22.00 | 1.26 | 1.42 | 2.8 | 4.2 |
| 3 | 10.0 | 31.08 | 1.27 | 2.63 | 2.9 | 4.4 |
| 4 | 17.5 | 27.80 | 2.31 | 3.36 | 3.0 | 4.3 |
| 5 | 12.0 | 21.30 | 1.28 | 1.36 | 2.3 | 3.0 |
| 6 | 12.0 | 27.20 | 1.29 | 1.66 | 2.7 | 3.4 |
| 7 | 18.0 | 26.00 | 1.34 | 1.39 | 2.8 | 3.5 |
| 8 | 28.4 | 36.10 | 1.52 | 3.53 | 4.2 | 5.1 |
| 9 | 27.8 | 36.00 | 1.38 | 3.48 | 3.8 | 5.0 |
| 10 | 26.0 | 33.00 | 1.28 | 2.64 | 3.5 | 4.7 |
| 11 | 26.5 | 34.20 | 1.28 | 1.7 | 3.5 | 4.8 |
| 12 | 25.5 | 33.90 | 1.25 | 1.32 | 3.9 | 4.7 |
| 13 | 9.0 | 12.60 | 0.26 | 0.70 | 2.0 | 3.1 |
| 14 | 0.2 | 0.07 | 0.00 | 0.01 | 4.1 | 3.92 |

**Fig. 1.0: Monthly Mean Values of Phosphate, Potassium and Nitrate Concentrations (mg/L)**



## REFERENCES

1. Ademoroti C.M.A. (1996): Standard Method for Water Effluents Analysis. Foludex Press Ltd. Ibadan, Nigeria. (pg 22-101)
2. American Public Health Association (APHA) (1975): "Standard Methods for the Examination of Water and Waste Water, 14th Edition APHA Office, Washington, p 234
3. Botkin, D.B. and Keller, E.A. (1998). Environmental Science. Earth as a Living Planet. 2nd Edn. John Wiley and Sons Inc, New York pp414-438.
4. Caincross, S. and Feachem, R.G. (1983). Environmental Health Engineering in the Tropics: An Introductory Text. John Wiley and Sons Ltd. New York pp. 26.
5. Cunningham, W.P. and Saigo, B.W. (1999). Environmental Science. A Global Concern. Mcgraw-Hill inc. New York, pp. 435-460
6. Enejoh J.O., Ako, P.A.E. and Lawani, S.A. (2002). Wet Season Water Quality in Minna Metropolis and Environs. Conference Proceedings. National Association of Teachers of Technology, 15th Annual Conference. Pp315-319.
7. Enejoh J.O (2002): Environmental Water Pollution: Some Pollutant Indices in River Suka, Minna, Niger State. Unpublished M. Tech. Thesis, FUT Minna.
8. Federal Environmental Protection Agency (FEPA 1991): Guidelines and Standard for Environmental Pollution Control in Nigeria.
9. Hellman H. (1987): "Analysis of Surface Water". Ellis Horwood Ltd. Chichester, England. Pg. 11-23
10. Nikoladze G., Mints D and Kastalsky, A; (1989) "Water Treatment for Public and Industrial Supply, MIR Publishers, pp 12-17.
11. PYE Unicam (1995); Spectrophotometric Method Sheet (x4) Published by PYE Unicam Ltd., Cambridge, England.
12. World Health Organization (1984): Guidelines for Drinking Water Quality. Vol 1-3. Printing , Geneva.
13. WHO. (1958) "International Standards for Drinking Water". 2nd Edn Geneva. Pp28.