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Determination of levels of phosphates and sulphates in domestic water from three selected springs in Nandi County, Kenya

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Abstract

This research was to estimate the levels of phosphates and sulphates in three selected springs. The analysis of phosphates requires good digestion which converts phosphorus to orthophosphate in the process. Therefore, ascorbic acid digestion method was employed in the phosphate analysis. The sulphates spectrophotometric analysis is based on the formation of colloids by sulphates and Barium chloride. With this method the greatest challenge was instability of conditioning reagent with time. Several timing trials were done to come up with the optimum time for reaction between the addition of conditioning reagent and sample analysis. Sampling was done at selected springs in Baraton Location, Sironoi Location and Kaptildil Location, all situated in Chesumei Constituency, Nandi County, Rift valley province in Kenya. The selected water springs are commonly used by residents for domestic purposes. The research showed that there is a significant level of phosphates and sulfates in all sampled water. Phosphates concentration were between the range of 2.79 mg/L to 622 mg/L, while sulphates were in the range of 109.8 mg/L to 250.98 mg/L.

Key-Words: Phosphates, Sulphates, Turbidimetry, Domestic Water, Spring

Introduction

Phosphates and sulphates exist in different inorganic forms in both soil and water. The source of phosphates can be artificial or anthropogenic depending on the activities occurring in the area under study (American Public Health Association, 1999). The use of phosphate based detergents has impacted on the water quality by introducing excess nutrients to the water. According to Egemen (2000), accelerated eutrophication may occur as a result of the phosphorus content of detergents in natural waters. Thus, the combined effects of excessive concentrations of detergents in natural waters may reduce oxygen concentrations, a change in water colour, increased turbidity and sedimentation, and a decrease in biological activity. In most developing countries, discharges from point sources have increased significantly as a result of industrialization and high living standards. Additionally, excessive nutrient loads to rivers in these countries have been accompanied by untreated wastewater discharges (Smith *et al.*, 1999).

Different methods of phosphate analysis have been developed; phosphomolybdate method has been used due its ease to its application. Spectrophotometric methods are based on the formation of yellow molybdophosphoric acid and its reduction to a blue heteropoly compound, phosphomolybdenum blue (Standard Methods, 1998; Lyddy-Meaney *et al.*, 2002; Zhang and Chi, 2002). The addition of phosphorus, as phosphate ion, to natural water is one of the most serious environmental problems because of its contribution to the eutrophication process (Khan *et al.*, 2007). The presence of phosphates in water is permissible to some extent; however the increased infiltration into water bodies is of international concern due to its effects on water quality. The threshold value of phosphate for drinking water is 0.1mg/L (Razman *et al.*, 1999). Sulphates is widely distributed in nature and may be present in natural water in substantial concentration. Sulphates occur naturally in numerous minerals, including barite, epsomite and gypsum (APHA, 2003).

According to World Health Organization 2004, typical sulfate levels in fresh spring water are in the vicinity of 20 mg/L and range from 0 to 630 mg/L in rivers. High doses of sulphate particularly magnesium sulphates, cause catharsis or purging of the bowels, and magnesium sulphate or Epsom salts has been used as a

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purgative (Cocchetto *et al.*, 1981). The taste thresholds of sulphates are 200-500 mg/L for sodium, 250 mg/L for calcium and 400-600 mg/L for Magnesium (Zoeteman, 1980). Turbidimetric analysis of sulphates is based on the formation of insoluble barium sulphate. This reaction forms colloids of uniform size and its formation is enhanced in the presence of sodium chloride, hydrochloric acid and glycerol. The sulphate content in water is important in determining the suitability of water for public and industrial use. Sulphate may also contribute to the corrosion of pipelines in the distribution system (Mariraj *et al.*, 2013).

The quality of water is deteriorating due to inorganic anions and cations being released from domestic and industrial effluent. By the year 2030, when Kenya will have attained an industrial economy, domestic and Industrial water will be a scarce resource. Most of the groundwater will be highly polluted and some of the water bodies will be covered by vegetation as a result of eutrophication and render the water non-potable. According to a report by Kenya Bureau of Standards, the territorial area of Kenya is 582,646 km² with 11,230 km² (1.927%) under surface water while the rest 571,416 km² (98.073%) on land. 85% of the land area is classified as Arid and Semi-Arid Land (ASAL) therefore making the only remaining 15% sustain more than 75% of the population. The average annual water available is 20.2 billion m³ which corresponds to 647 m³ per person per year. This classifies Kenya as a water scarce country since it falls way below the 1,000 m³ per person per year threshold.

The main aim of this investigation was to determine the levels of sulphates and phosphates in spring water in a highly agricultural area.

Material and Methods

Sampling and Storage

The most important task of water quality analysis is sampling (Abdur, 2013). Spring water samples were obtained from Sironoi, Baraton and Kaptildil spring sources using brown reagent bottles that had been prewashed with nitric acid, detergent and rinsed with distilled water several times. A total of 12 samples were collected for analysis, four from each spring. The samples were tightly capped and placed in a cool box immediately. They were then transported to the laboratory, and then filtered using whatman filter papers to avoid interference due to turbidity and color. The samples were then kept in a refrigerator at a temperature below 4°C.

Conditioning Reagent

25ml of glycerol was measured and poured into a clean dry beaker. 15 ml of concentrated hydrochloric acid

was added into the same beaker and shaken. To the same beaker, exactly 50 ml of 95% isopropanol was added and mixed well. 37.5 g sodium chloride was weighed and dissolved in distilled water. All the contents were mixed and made up to 250 ml with distilled water.

Standard Sulphate Solution

The standards used for sulphate was prepared by weighing exactly 1.479 g of analytical grade anhydrous sodium sulphate and dissolved in distilled water and made to a volume of 1000 ml in a standard volumetric flask using distilled water. This solution is equivalent to 1000 ppm Sulphate (1ml=1.0 mg SO₄²⁻).

Preparation of Blank, Standards and Samples for Analysis

10 ml of Standard Sulphate solution was measured to the first flask, 20 ml to the second, 30 ml to the third, 40 ml to the fourth, and 50 ml to the fifth. To the sixth flask was added distilled water alone and labeled as blank. All the six flasks were topped up to 100 ml mark of volumetric flask and capped tightly.

The samples were prepared by pipetting 10 ml of each sample into a 25 ml standard volumetric flask. 5 ml of the conditioning reagent was added independently to each sample and the standards after every 3 minutes. The analysis was done at a wavelength of 420 nm using An Advanced Microprocessor UV-VIS Spectrophotometer Single Beam 295.

Preparation of Phosphate Standards

The standards were prepared according to the standard methods for the examination of water and Waste Water (APHA, 1999).

1000 ppm of standard phosphate solution was prepared by weighing exactly 1.4329 g of analytical grade potassium dihydrogen orthophosphate and diluting to 1000 ml in a standard volumetric flask using distilled water. 0.1 ml, 0.2 ml, 0.3 ml, 0.4 ml, 0.5 ml and 0.6 ml of the standard phosphate solutions were accurately pipetted into a 100 ml volumetric flask using 1ml pipette equivalent to 1-6 ppm.

Preparation of Combined Reagent

5N sulphuric acid was prepared by measuring 14 ml of 98% concentrated sulphuric acid into a 100 ml volumetric flask and diluting to the mark with distilled water. 0.2743 g of potassium antimonyl tartrate was accurately weighed into a 100 ml volumetric flask and diluted with distilled water to the mark. 4g of ammonium molybdate was weighed and put into a 100 ml volumetric flask and 1.76 g of ascorbic acid in 100 ml. To prepare the combined reagent, 50 ml of 5N sulphuric acid, 5ml potassium antimonyl tartrate solution, 15ml ammonium molybdate solution, and 30

ml ascorbic acid solution was measured into a 100 ml volumetric flask.

Phosphate Analysis

10 ml of each of the standards, blank and samples were measured into a test tube. 2 ml of combined reagent were added to the standards, blanks and samples. 1 drop of phenolphthalein indicator was added to the solutions upon which pink colour develops and 5N sulfuric acid was added drop wise to discharge the colour. Ten minutes was allowed to elapse, after which absorbance of each solution was measured at 880 nm on a UV-VIS spectrophotometer.

Results and Discussion

The analytical results of the study have been shown in table 1. The highest concentration of sulphates was obtained from Kaptildil Source D with a concentration of 250.98 mg/L, the lowest being Kaptildil Source C at 109.80 mg/L. Even though there is no health-based guideline proposed for sulphate, intake of high sulphate levels has gastrointestinal effects. It is recommended that health authorities be notified of sources of drinking water that contain sulfate concentrations in excess of 500 mg/L. The presence of sulphate in drinking-water may also cause noticeable taste and may contribute to the corrosion of distribution systems (WHO, 2008).

The highest phosphate levels was recorded at Baraton source A with a concentration of 622.01mg/L, while the lowest concentration was 2.79 mg/L recorded at Sironoi spring source D. 92% of the sampled water had phosphate level beyond the WHO recommended maximum of 5 mg/L. This would pose health effects such as osteoporosis and kidney damage.

The highest concentration of phosphates at Baraton source A could be attributed to the farming activities being undertaken where there is heavy use of phosphate fertilizers. It could also be due to laundry activities being performed by residents of Baraton Centre next to this water source using phosphate containing detergents.

When the concentration of phosphates rises above 100 mg/L the coagulation processes in drinking water treatment plants may be adversely affected. Manmade sources of phosphate include human sewage, agricultural run-off from crops, sewage from animal feedlots, pulp and paper industry, vegetable and fruit processing, chemical and fertilizer manufacturing, and detergents (John W., 1993).

The elevated phosphate concentrations in water have been linked to increasing rates of plant growth, changes in species composition and proliferation of planktonic and epiphytic and epibenthic algae, resulting in shading of higher plants (Mainstone and Parr, 2002).

Conclusion

From the investigation, the sulphate levels are within the acceptable range in all the sampled springs. Phosphate concentration was generally at elevated levels in most of the sampled points. Therefore Sustainable farming methods should be encouraged to avoid influx of nutrients into the water bodies and impact on the quality of domestic water systems. More research work need to be undertaken during different seasons of the year to ascertain the two inorganic ions in water bodies and the variations in the concentrations during different times of the year. The main delimitation was the possible interference by other factors in the phosphate analysis. Therefore further analysis of interference should be performed to ensure the samples are free from any form of interference like heavy metals. Analysis of phosphates can be improved by applying the high point standard method which prevents the interference due to silicates based on the rates of reactions between the phosphate and silicates. The kinetics of formation of a complex between molybdenum ions in the presence of silicates and phosphates can be applied for water analysis.

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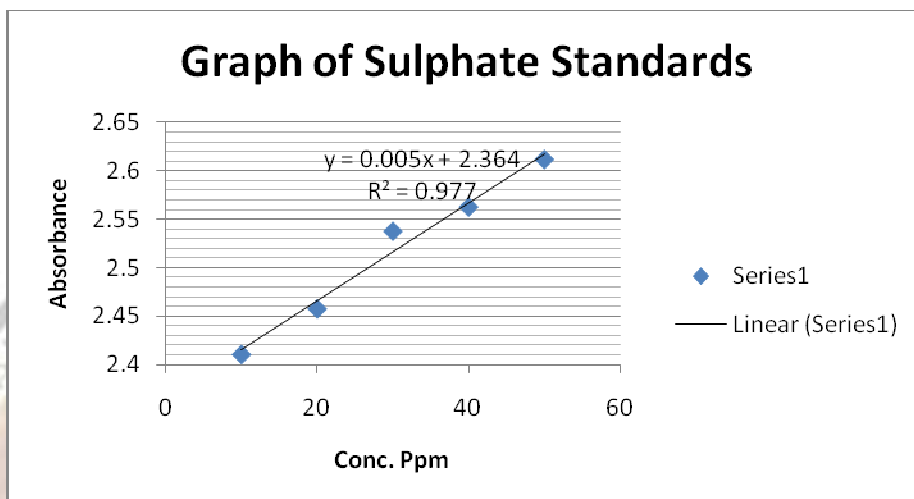


Fig. 1: Standards Measured at a Wavelength of 420 nm

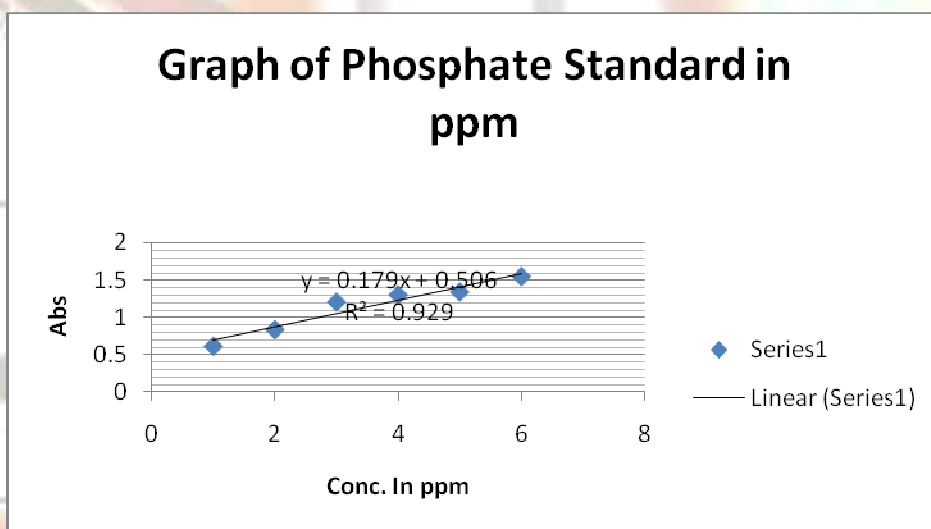


Fig. 2: Phosphate Standards measured at a wavelength of 880 nm

Table 1: Phosphates and Sulphates Sample Analysis

Sample location	Absorbance	[SO ₄ ²⁻] mg/L	Absorbance	[PO ₄ ³⁻] mg/L
Sironoi Source A	0.046	180.39	0.030	16.76
Sironoi Source B	0.055	215.69	0.016	8.93
Sironoi Source C	0.044	172.55	0.044	24.46
Sironoi Source D	0.050	196.08	0.005	2.79
Baraton Source A	0.054	211.76	1.119	622.01
Baraton Source B	0.046	180.39	0.012	6.70
Baraton Source C	0.030	117.65	0.015	8.38
Baraton Source D	0.044	172.55	0.022	12.29
Kaptildil Source A	0.047	184.31	0.014	7.82
Kaptildil Source B	0.052	203.92	0.114	63.68
Kaptildil Source C	0.028	109.80	0.020	16.79
Kaptildil Source D	0.064	250.98	0.047	26.25

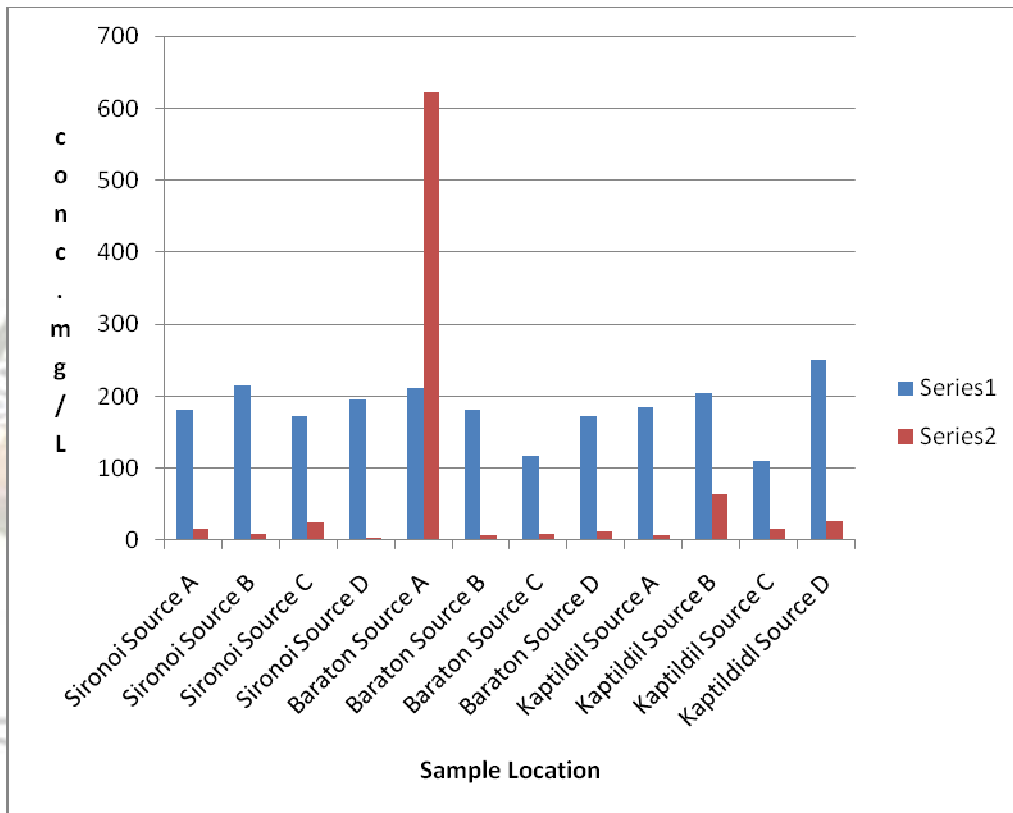


Fig. 3: Concentration against Sample Locations

Fig. 3: is a graphical representation of the concentration of both phosphates and sulphates in the sampled springs