NATIONAL UNIVERSITY OF LESOTHO

DEPARTMENT OF CHEMISTRY AND CHEMICAL TECHNOLOGY

The Effect of Phosphate Detergents Discharges and the Application of Fertilizers on the Water Quality of Liphiring River

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A project report submitted to the Department of Chemistry and Chemical Technology in the Faculty of Science and Technology in partial fulfillment of the requirements for the award of the degree B Sc. Chem. Tech.

Supervisor: Dr E.B. Tanor **Roma, May 2011**

Declaration

I do hereby verify that this written project report has never been done before in any previous fulfillment of degree in BSc in Chemical Technology. All the work in this report has been done by me and all the source of information have been properly acknowledged by reference.

Signature: R.Tlali

Date: May 26, 2011

Dedication:

This project report is dedicated to my friends and family at large for the support, understanding, motivation and encouragement they have shown to me.

Acknowledgements:
I wish to acknowledge with thanks my supervisor Dr E.B Tanor for guidance and assistance he gave me. In addition I appreciate Mrs Malijana for; her patience, and providing me with the reagents when ever I needed them. Lastly I am grateful to my colleagues and all those who were involved for the successful completion of this project report.

Abstract:

Sewage from the waste treatment ponds serving the university community in Roma, water samples from the Liphiring River and soil samples from the croplands along the river banks were analyzed for some selected parameters. The values for the physical parameters pH, temperature, conductivity, total dissolved solids and turbidity suggest that the discharge of the wastewater into the river does have much negative impact on the water quality. Also, the levels of chemical parameters suggest some degree of contamination. The levels of nitrites and sulphates are higher in the sewage thus the effluent discharge contributes to levels in the river. The levels of phosphates and nitrates are higher in soil thus the soil contributes to levels in river water due to leaching and run-offs.

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Chapter 1. Introduction

The Liphiring River is one of the rivers in the Roma community in Lesotho. This river supports most of the human activities in the Roma valley. It serves as a source of irrigation water, livestock watering and some household d chores like laundry, washings etc. except for drinking and cooking. The river flows into the Phuthiasana River, which is a source of potable water for many communities along its course. The rivers also serve as habitats for several kinds of animals and plants life other aquatic organisms.

The water quality of Liphiring River is influenced by soil erosion, and activities occurring in the river basin. The major ones being sewage effluent discharges, human and agricultural activities, storm-water run-offs. Some communities along the course of the river dispose their household wastes in the river because of the lack of waste proper sewers and disposal sites. As a result, the river water is contaminated with various substances that are used in modern society. Heavy metals and other chemicals from the municipal sewage and stormwaters and run-offs from the croplands along the river banks, are introduced into the river hence contributing to the color of the water of Liphiring River. The communities in the river basin do all their laundry in the river thus leading ~~to~~ contributing to a direct addition of phosphates into the river.

Soil erosion in the river basin has a major impact on the water quality. Soils erosion has a major problem in Lesotho, because of the nature of the topology of the land and lack of vegetation cover. The river receives a lot of silt, especially during the wet seasons when precipitation is high. This sometimes affects some physical properties of the river water, such as the colour, total dissolved and suspended solids and turbidity. Unsustainable forest practices of the nearby communities lead to soil erosion, which in turn results in increased turbidity and sediment loading

All the treated and untreated sewage in the Roma community is discharged into Liphiring River thus it is the major source of pollution of the river. Of all the possible pollutants in the sewage the major ones are the pathogenic microorganisms, phosphates from detergents, nitrates, and household chemical residues. In general, human activities within the river basin cause changes in river ecology and environment which in turn produces changes in the availability of aquatic life hence causing changes in food security and livelihoods of the communities which depend on the rivers.

1.1. Inflow of stormwaters

Inflow of stormwater refers to water entering the wastewater connection through incorrectly connected sump pumps, foundation drains or other sources. Sources of inflow include drains from driveways, outdoor basement stairwell drains, and drains from window wells, roof drains, and faulty manhole cover, and uncapped cleanout, storm cross connection and foundation drains. Infiltration is the groundwater that enters the wastewater system via cracks and or leaks found in the wastewater pipes. Infiltration sources include sanitary sewer main, broken side sewer, faulty lateral connection, and roof intrusion into side sewer, deteriorated manhole, broken pipe and storm sewer.

During heavy rains, large amounts of storm water within the Liphiring River basin lead to overflows of untreated wastewater at freshwater ~~and marine~~ environments causing public and environmental health risks. Occurrence of overflows in this river basin depends on the duration and intensity of rainfall events.

1.2. The state of wastewater treatment in Maseru

Based on water and environment sustainability, it is necessary for every country to treat wastewater and this is further emphasized by water quality management policy which states that; member states should adopt necessary measures to control and prevent pollution of surface and ground waters (SADC Regional Water Policy, 2006).

In Maseru, wastewater is treated at Water and Sewage Authority (WASA) plant located at Ha-Ratjomose. The main objective of this plant is to treat wastewater in order to protect the environment and public health by removing some of the bacteria in wastewater that are harmful to humans and wildlife. Removal of these bacteria and other pollutants requires a three stage treatment process which combines physical, chemical and biological processes and operations.

Primary treatment is a physical process of removing solid particles by means of using screens and by allowing settling in a settling tank. Secondary treatment uses biological treatment processes such as activated sludge, where the sludge contains bacteria to digest the waste, trickling filters where aerobic bacteria are allowed to work on the waste. Tertiary treatment use chemical or biological processes to remove nutrients and disinfect the wastewater.

Screening is the process of applying screens to the waste water to remove solid particles such as leaves, stones, paper and plastic. This is used to remove solids up to the size of 1mm. when particles below 1mm sizes are present sedimentation can be used to remove them.

Some time the impurities in water are so small that they cannot be removed by screening or sedimentation. Such particles are colloidal suspensions and are removed by the process called flocculation. Flocculation makes these small particles join together and hence denser heavier particles are then removed by sedimentation. Coagulation is also used to achieve even greater extent of removal of solids; coagulation is the process of using metals to attract tiny solid particles.

The principle of biological treatment of wastewater is that micro-organisms are allowed to feed on organic waste in wastewater and cleanse it in the process. Under aerobic treatment, aerobic bacteria are the ones that are used in the presence of oxygen. In anaerobic treatment, anaerobic bacteria work in the absence of oxygen to clean wastewater.

1.3. History of detergents

Detergents are sodium salts of alkyl hydrogen sulphate or sodium salts of long chain alkyl benzene sulphonic acids. Due to shortage of fats for manufacturing soaps, detergents were developed by the Germans during the World War I in the year 1916 (Peter and Paul, 2006). Their evolution replaced the use of organic soap in areas of hard water and in the textile industry where acidic solutions are used in the drying processes. Thus the invention of detergents was based on the need for a cleaning agent, which would not react with calcium and magnesium ions in hard water to form a precipitate and spots on fabrics.

The earliest developed synthetic detergents were short chain alkyl naphthalene sulphonates, but these were later discovered to be moderately good detergents hence were used as wetting agents. During 1920’s and 30’s straight chain detergents were produced from sulphonation of straight chain alcohols, also during this period, long chain alkyl and aryl sulphonates with benzene were established as the aromatic nucleus. Alkyl aryl sulphonates swamped the market of detergent over alcohol sulphates at the end of World War II (Peter and Paul, 2006).

Carboxyl methyl cellulose was added in detergents because the synthetic detergents failed to hold dirt in suspension resulting in particles being redeposited onto the clothing. Recently the availability of raw materials affected production of detergents, thus the market of alkyl benzene sulphonate was high because of its ease of versatility and manufacture. The main application of first synthetic detergents were in hand dish washing and fine fabric laundering, in 1946, the detergents containing builder and surfactant were developed and these were used in laundry (Jensen, 1990). Surfactant is a fundamental cleaning agent of the synthetic detergent while the builder aids the surfactant to function effectively.

Between 1950 and 1965 synthetic detergents based on propylene tetramer conjugated to benzene were produced, but these resulted in eutrophication in lakes and streams as they contain phosphates (Jensen, 1990). This problem was solved by production of branched chain formation of propylene tetramer coupled to benzene, but these were not degradable by bacteria. Procedures were conducted to produce a linear alkyl benzene molecule as straight chain alcohols that are degradable. In Scandinavian countries, phosphate was substituted with nitrilo triacetic acid.

A surfactant is a working molecule in the detergent and it is also the substance that significantly minimizes the surface tension of water. When used in low concentrations, this then result in the stain being cleaned to be dispersed suspended and then washed away. Surfactant is the active component of the detergent and it consists of hydrophobic head which attracts oil particles and also hydrophilic head which attracts the water molecules. The general formula of detergent is

$CH_3\,(CH_2)_8OSO_3Na$. The categories of surfactants used in household detergent include anionic, cationic, non-ionic and amphoteric surfactants

A detergent builder is an auxiliary component in the detergent which helps the surfactant to perform the cleaning. Detergent builders including inorganic builder such as phosphate and organic builder such as polycarboxylate polymer may be used. Phosphate builder that may be used include sodium tripolyphosphate which may be combined with sodium orthophosphate and/or sodium pyrophosphate.

Alkyl sulphate detergents are derived from natural fats and fatty oils by reducing them to alcohols, then sulphating with a sulphating agent such as sulphuric acid and neutralizing the sulphated product with the appropriate base such as sodium hydroxide to form water soluble salts. For example, sodium lauryl sulphate is synthesized from lauryl alcohol as follows:

$CH_3\,(CH_2)_{11}OH + H_2SO_4 + NaOH \rightarrow CH_3\,(CH_2)_{11}\,OSO_3\,Na$ …………………………... (7)

1.4. Regulation concerning alkyl benzene sulphonate

Alkyl benzene sulphonates (ABS) are mainly used in food processing plants and eating establishments as food-contact sanitizers. They are further used as disinfectants for industrial, institutional, commercial, and agricultural and public access. The United States Environmental Protection Agency (US EPA) issued its risk management decision after completing its review of error correction, preliminary risk assessments, comments on the health of human and the environmental risk assessments for alkyl benzene sulphonate. The eligibility of ABS was based on measures undertaken in risk assessments as outlined below (Barid, 2003).

Based on ABS, three chronic dietary exposure and risk assessments were conducted; first as the active component in food in contact with sanitizing solutions, second as the active component in vegetables and fruits washed with detergents and lastly as the active component in pesticides formulation used on animals, for growing agricultural crops and to raw agricultural commodities after harvest. Acute dietary assessment was not performed due to absence of harmful effects attributable to a single dose in animals. The dietary risk approximations for the active component and the overall food contact sanitizing uses were less than the EPA's level of concern for all the age groups, also the dietary approximations for the fruit and the vegetable wash were less than the EPA's level of concern for all the age groups. Dietary risk approximations for the inert component uses were less than the US EPA's level of concern for the general US populations and all the population subgroups.

No concern was present for aggregate drinking water and fruit exposures to the ABS due to their use as inert components in pesticides. The chronic dietary risk assessment decided that risk approximations were below the US EPA's level of concern for the overall U.S population and all subpopulations.

Outdoor uses of ABS as the active components were not registered, but the Agency approximated drinking water concentrations from inert component uses of the substances because there was a possibility of leaching of these substances into drinking water. Acute drinking water risks for inert component uses were not approximated due to unselected acute dietary end point as no effects attributable to a single dose exposure in animals were observed. The EPA decided that no risk concerns were present for the overall U.S population and all population subgroups for the drinking water exposure to the ABS as pesticide inert components.

1.4.1. Residential risk assessment

Residential handler and post-application exposure scenarios were analyzed by the use of rates for inert uses, end-use product application methods and high end exposure scenarios. The EPA analyzed residential handler inhalation exposure and post application minor ingestion by small children for each of the use scenarios. Overall margins of exposure (OME) for acute inhalation exposure for residential handlers were exceeding the target margins of exposure of 100(WorldBank, 1998) thus it was not important. As a result the EPA did not find the risk concerns.

1.4.2. Aggregate risk assessment

The long-term aggregate analysis focus on the mean dietary exposure from the inert uses on agricultural commodities and the active food conduct sanitizer uses. But dietary exposures from the vegetable and fruit wash were neglected as it would have been overly conservative to approximate exposure to ABS from three separate use patterns. Risk approximations, oral and inhalation exposure were added for adults because of their total margins of exposure of 340(Higgins, 1995) which is exceeding the target margins of exposure. For children the aggregate risk approximation was 99(Higgins, 1995) hence it was close to the target margins of exposure. Long term aggregate analysis found no risk of importance for adults and children. The EPA did not have any risks of importance for children.

1.4.3. Occupational risk assessment

The EPA's human health risk assessment showed that there are four occupational handling-inhalation scenarios with OME number ranging between 90 and 93(Kuhnt, 1993). For some of the occupational scenarios, post application dermal exposure was neglected relative to the application rates and chemical properties of ABS. all the labels need the workers to use cloves as ABS are irritating the skin at concentrations exceeding 0.2(Kuhnt, 1993).

1.5. Phosphates in synthetic detergents and water pollution

Phosphorus is an important component for the growth of organisms including their photosynthesis and metabolic activities. Phosphorus in water bodies is largely in the form of phosphates; phosphorus is the building block for the teeth and bones and is used for transferring energy within the cell and all functions of the body from thought to motion. Phosphorus is naturally present in food and is ingested as phosphates, phosphates are the principal nutrients in large number of agricultural and garden fertilizers due to their importance for plant growth but sometimes their release into rivers may lead to environmental problems. Because of continuous addition of phosphates by natural processes and human activities, the concentration of phosphates in the river is increased hence speeding up the growth of phosphate-dependent organisms including algae. This growth leads to oxygen deficiency and prevents entry of sunlight into the river thus leading to eutrophication.

Phosphates are also present in fertilizers and in consumer products such as synthetic detergents. They are categorized as orthophosphates and polyphosphates. The former are used for biological metabolism without further breaking down in aqueous solution. If applied on cultivated lands as fertilizers then they may be introduced into the river by storm runoff, melting snow and soil erosion. Natural phosphate source include natural bed-rock. Phosphates may be added in water when cleaning since these exist as builders in synthetic detergents. Polyphosphates hydrolyze slowly in aqueous solutions to yield orthophosphates which eventually results in entrophication.

Sodium tripolyphosphate (STPP) is used as detergent builder. Two principal sources of phosphate inflow into the river are municipal wastewater and agriculture. The principal agricultural sources originate from use of synthetic chemical fertilizers and animal husbandry with erosion and runoff being the main transport pathways for phosphates into the river.

On the basis of the results obtained from life cycle analysis, zeolite A was found as an alternative detergent builder. It does not cause entrophication, produces less harmful waste by-products when extracting it from bauxite than the extraction of phosphates from phosphate rocks and it is not harmful to humans and aquatic organisms. Hence zeolite A is cost-effective both in socio-economic and environmental impacts.

Water quality management involves implementation of measures that minimize phosphorus and nitrogen concentrations in fertilizers. Apart from effluent regulations and water quality guidelines, some developing countries include water quality within a national water policy context. This policy may include a policy framework that gives political and strategic directions for future water quality management. The control of water pollution is an essential part of water management and has essential consequences on human health, economic activity and development. Polluted water imposes high costs to the environment and the society, this resulted to the establishment of the pollution legislation which include specifying standards, issuing licenses and permits, and land use control (Maxwell et al, 1996).

Water pollution refers to physical, chemical or biological changes in water quality resulting in adverse effects to living organisms which depend on water (Barnes et al, 1981). Water pollution results when the water body is harmfully affected due to presence of large amounts of materials in the water. This type of pollution is determined in the laboratory by analyzing small samples of water for different contaminants. Water pollution normally arises as a result of human activities.

Sources of pollution may be classified into point and non-point sources. The former occur when toxic substances are emitted directly into the water body, examples include; agriculture, sewage treatment plants and factories. The latter occur when pollutants are delivered indirectly through environmental changes, examples include; pollutants that enter water through ground water and pollutants that are spread in rivers.

The main sources of water pollution may be categorized as industrial; based on application of agrochemicals and industrial wastewater, agricultural; based on the application of chemical fertilizers and pesticides, and municipal; based on sewage disposal. Industry is one of the sources of water pollution as it generates toxic pollutants to human and the environment. Industrial waste contains mercury, lead, asbestos, petrochemicals, oil and sulphur. Mercury is non-biodegradable and may cause adverse effects to humans and the environment. Lead is non-biodegradable, inhibits action of the enzymes of the body and is toxic to humans and other animals. Asbestos has adverse health effects because it results in illness such as asbestosis when inhaled. Petrochemicals have potential to cause harm to marine life. Oil may inhibit photosynthesis of marine plants as it forms a thick layer on the surface of water and sulphur is toxic to marine life.

Water pollution is also increased by agricultural practices including fertilizers and pesticides. Continuous use of fertilizers indicates that phosphates and nitrates are more being washed from the soil into the river leading to growth and rapid reproduction of phytoplankton. This results in algal blooms which influence the normal functioning of the ecosystem and hence leading to entrophication.

Agrochemicals also lead to water pollution, and conventional agriculture in Southern Africa relies mainly on pesticides and herbicides thus resulting in high chemical pollution. Pesticides are non-biodegradable, persist in the environment for a long time, absorbed in living organisms and accumulate along food chains. Examples include insecticides, fungicides and molluscicides. When pesticides are used for public health or in agriculture, they enter aquatic environments and lead to development of resistant strains of organisms, harm species that are beneficial to humanity and case changes in the ecosystem. One of the most dangerous insecticides is dichloro-diphenyl-trichloroethane (DDT) due to its high toxicity; it has been banned worldwide but is still used legally in some countries, for example, in northern Namibia, for control of the tsetse fly (Lester and Woodward, 1972). Fertilizers contain phosphates, nitrates and compounds. Fertilizer run off increases supply of nutrients in the river causing algae to bloom artificially, die off and decay, using up oxygen needed by fish and other organisms. Nitrogen fertilizers may acidify the soil hence causing destruction of some living organisms. High levels in drinking water may lead to miscarriages and blood poisoning in young children.

Atmospheric deposition is another source of water pollution; weak acid is formed in the atmosphere due to the reaction of carbon dioxide, sulphur dioxide and nitrogen. This acid rain cause adverse effects to aquatic life during rainy seasons.

Chapter 2. Aims and Objectives

In Lesotho detergents are used in everyday life. The major hazard of phosphate detergent and nitrate pollution lays in their impact on water ecosystem as a whole. Excessive phosphate and nitrate loads to rivers in Lesotho are accompanied by untreated wastewater discharges and agricultural practices. Detergents may adversely affect microalgae at the lowest trophic level and impact on their function as the main suppliers of oxygen to water bodies (Patin, 1985). Also detergents affect receiving aquatic arena by limiting oxygen production, causing foaming, causing eutrophication and posing a hazard to waters used for potable supply (Vural and Kumbur, 1982). Surface foams block aeration of water bodies and their decomposition increase biochemical oxygen demand thus depleting dissolved oxygen levels. The combined effects of excessive phosphate and nitrate concentrations in natural waters may be reduced oxygen concentrations, a change in water colour, increased turbidity and sedimentation and a decreased biological activity.

This research project was conducted in order to study the effect of phosphate detergent discharges and the application of fertilizers on the water quality of Liphiring River.

Chapter 3. Experimental

3.1. Apparatus

Hach DR/2000 spectrophotometer, plastic bag, plastic bottles, metal ring, mortar, Whatmann filter paper and refrigerator.

3.2. Reagents

Sodium carbonate, hydrochloric acid, distilled water, PhosVer 3 Phosphate Powder Pillow, Nitra Ver 5 Nitrate Reagent Powder Pillow, NitraVer 3 Nitrite Reagent Powder Pillow and SulfaVer 4 Reagent Powder Pillow.

3.3. Sampling

The map below shows the sapmling points.

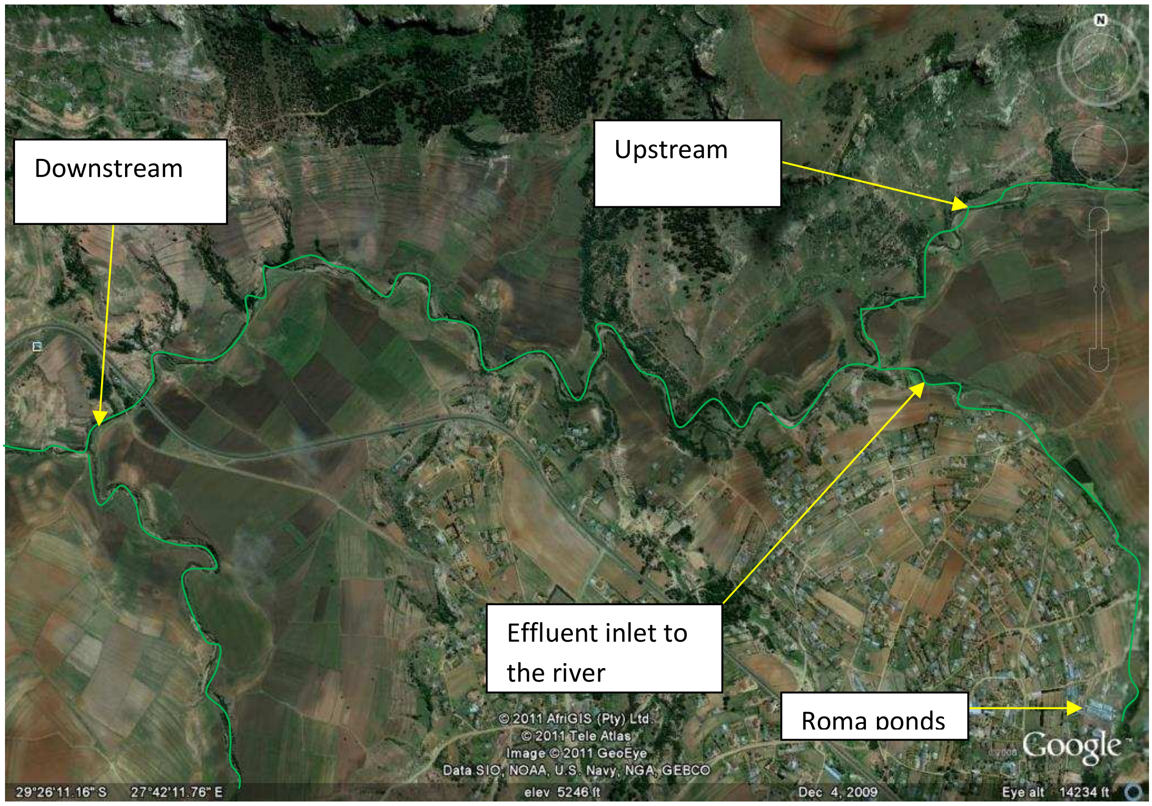

Figure 1: Location of Liphiring River and the water sampling points.

The location and sampling points are shown in figure 1. The sampling points were selected based on the activities along Liphiring River. Raw sewage samples and from the sewage ponds at serving the university community and the Roma valley. Water samples were collected at upstream and downstream relative to the point where the discharged treated sewage enters the river. Sampling was done using plastic bottles as containment and storing them in the refrigerator at 4 ^{o}C in the laboratory before analysis. Soil samples were also collected from the croplands along the river banks. The samples were stored in the plastic bags and analyzed after one day. Metal ring was used to dig a slice of soil within 20 cm from the soil surface.

3.4. Sample preparation

Before analysis, water samples were warmed to room temperature and filtered to remove any suspended or insoluble solids. The soil was dried in air at room temperature. 1.5g of soil was crushed with a mortar then dissolved in 5% Na_2CO_3 for determination of phosphates, nitrates and nitrites. For sulfate determination of sulphates the weighed portion of the soil was digested in 5M HCl.

3.4.1. Determination of phosphates

For determination of phosphates; the sample cell was filled with 25 mL of the prepared sample, the contents of one PhosVer 3 phosphate Powder Pillow were added with the sample. A blue colour developed after 2 minutes, the cell was then wiped and inserted into the cell holder of HACH Direct Reading UV-Visible spectrophotometer, DR-2000 at the wavelength and reading the concentration of phosphates at 890nm. (DR-2000 spectrophotometer manual)

3.4.2. Determination of nitrates

For determination of nitrates; a 25 mL sample cell was filled with the prepared sample to the mark, the contents of one NitraVer 5 Nitrate Reagent Powder Pillow were added with the sample. A vigorous reaction occurred for 1 minute and an amber colour developed after five minutes. Then prepared sample was then inserted into the cell holder of HACH UV-Visible Direct Reading UV-Visible spectrophotometer, DR-2000 and hence reading the concentration of nitrates at wavelength 400nm. (DR-2000 spectrophotometer manual)

3.4.3. Determination of nitrites

For determination of nitrite; sample cell was filled with 25 mL of the prepared sample, the contents of one Nitri Ver 3 Nitrite Reagent Powder Pillow were added to prepared sample and were completely dissolved. A pink colour developed after 15 minutes. The cell was then inserted into the cell holder of Hach UV-Visible spectrophotometer and hence reading the concentration of nitrites at 507nm. (DR-2000 spectrophotometer manual)

3.4.4. Determination of sulfates

Also for determination of sulfate; the sample cell was filled with 25 mL of the prepared sample, the contents of one Sulfa Ver 4 Reagent Powder Pillow were added to the sample, and a cloudy solution was formed after 5 minutes. The cell was then inserted into the cell holder of UV-Visible spectrophotometer and hence reading the concentration of sulfates at 450nm. (DR-spectrophotometer manual)

Chapter 4. Results and discussions

The results of the physical parameters are presented in figure 2. The chemical parameters are shown in figures 1, 2, 3 and 4 for phosphates, nitrates, nitrites and sulfate respectively. The pH for the upstream, downstream and sewage is 8.02, 6.53 and 7.84 respectively and all the pH values observed were within the pH tolerance limit of 6.00-9.00 (US-EPA, Clean Water Act). It can thus be concluded that the pH does not impact negatively on aquatic life of freshwater fish and bottom dwelling invertebrates in all areas sampled.

The observed temperature at upstream, downstream and sewage is 17.2, 15.2 and 21.5 ^{o}C thus there is higher rate of solubility of solids, chemical and metabolic reactions at upstream than at downstream. Higher amount of dissolved oxygen at downstream than at upstream also resulted. Turbidity was obtained as 0.98 all the sampling points. Graph of physical parameters is shown below.

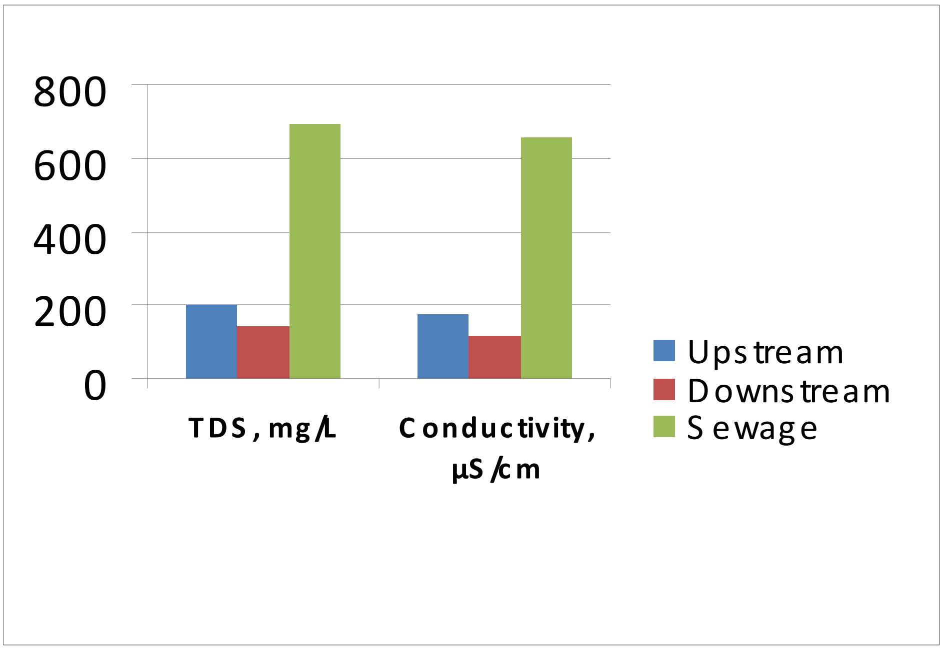

Figure 2: : Chemical parameters of the river and sewage

The conductivity values were 175.3, 118.2 and 695 µS/cm at upstream, downstream and in sewage respectively. There is higher mineralization at downstream than at upstream. The values for the total dissolved salts were 204, 145 and 682 mg/L, respectively thus there is higher amount of dissolved salts, organic matter and minerals at downstream than upstream.

The concentration of phosphate and nitrate is highest in the soil samples, 4.57 and 3.5 mg/L respectively. This may be due to application of fertilizer in agricultural practices on the riverside. The concentration of phosphate is exceeding the recommended level in the river water, 0.1 mg/L (Clean Water Act), thus this may be mainly polluting the Liphiring River, and eutrophication may also result thereby leading to the death of fish and aquatic organisms. The amount of nitrate is below the contaminant level, 10 mg/L (Clean Water Act), in all areas sampled thus this water may be used for drinking. The graph of phosphates in the samples is shown below.

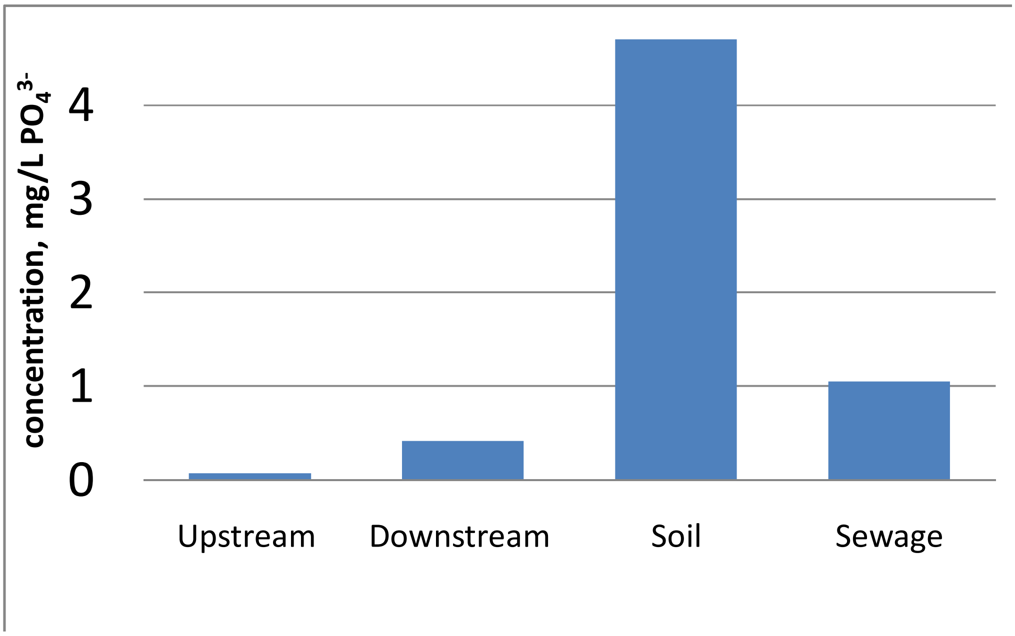

Figure 3: concentration of phosphates in the river, sewage and soil

The concentration of nitrite and sulfate was highest in the sewage and these were below the maximum contamination levels in the river, 1.0 mg/L and 250 mg/L respectively (Clean Water

Act). Thus this water may be used as a source of drinking water because the concentration of nitrate, nitrite and sulfate is also below the maximum contamination level in the drinking water. The graph below shows the concentration of phosphate, nitrate, nitrite and sulphates in the samples.

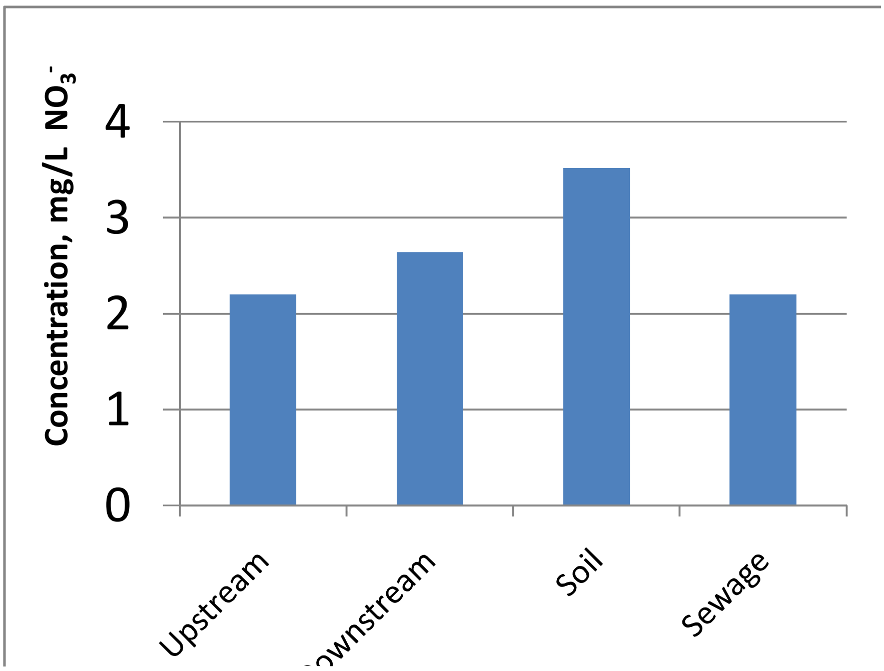

Figure 4: concentration of nitrates in the river, sewage and soil

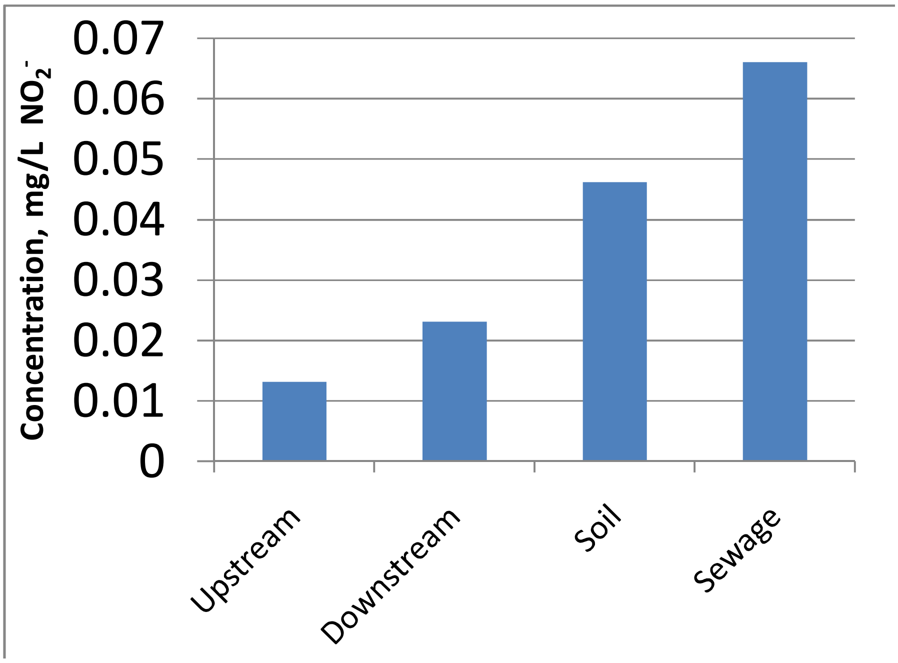

Figure 5: concentration of nitrites in the river, sewage and soil

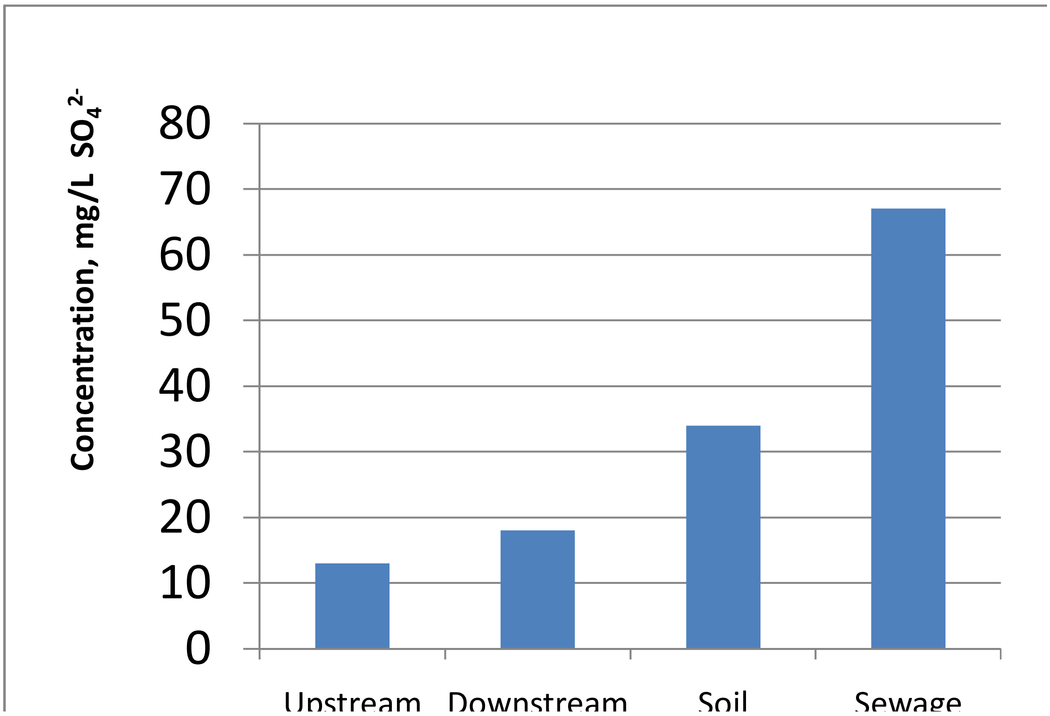

Figure 6: concentration of sulfates in the river, sewage and soil

The concentration of phosphates is 0.07±0.01, 0.42±0.01, 4.7±0.1 and 1.05±0.01 mg/L at upstream, downstream, soil and sewage respectively as shown in figure 1. The concentration of nitrates is 2.20±0.05, 2.64±0.08, 3.52±0.08 and 2.20±0.05 mg/L at upstream, downstream, soil and sewage respectively as shown in figure 2. The concentration of nitrites is 0.0132±0.0005, 0.0231±0.0005, 0.0462±0.0008 and 0.066±0.002 mg/L at upstream, downstream, soil and sewage respectively as shown in figure 3. Also the concentration of sulfate is 13.0±0.8, 18±1, 34±1 and 67±2 mg/L at upstream, downstream, soil and sewage respectively as shown in figure above.

Table 1: maximum contamination limits (MCL) for phosphates, nitrates, nitrites and sulphates in river water and potable water

Sample	PO_4^{3-}		NO_3^-		NO_2^-		SO_4^{2-}	
	Actual mg/L	MCL mg/L	Actual mg/L	MCL mg/L	Actual mg/L	MCL mg/L	Actual mg/L	MCL mg/L
Upstream	0.07	0.1	2.2	10	0.0132	1.0	13	250
Downstream	0.42	0.1	2.64	10	0.0231	1.0	18	250
Soil	4.7	0.1	3.52	10	0.0462	1.0	34	250
Sewage	1.05	0.1	2.2	10	0.0660	1.0	67	250

Source: *www.epa.gov/regulations/laws/cwa.html*

Chapter 5. Conclusion

The amount of phosphate is exceeds the maximum contamination levels for the river water thus the phosphate detergent discharges and the application of fertilizers containing phosphorus poses a potential threat to the Liphiring River. This may lead to increased eutrophication hence resulting in death of fish and aquatic organisms.

5.1. Recommendation

It is recommended that the effluent be further treated to reduce the phosphate levels before discharge into the environment. Further work should be done to confirm the conclusions made – the pollution by detergent phosphates and nitrate from chemical fertilizers.

Farmers should be given technical support on the use of chemical fertilizers to prevent their excessive application.

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