ASSESSMENT OF NUTRIENT POLLUTANTS IN SAMPLES OF WATER FROM SELECTED PARTS OF NAGONGERA STREAM LOCATED IN NAGONGERA DIVISION OF TORORO DISTRICT, EASTERN UGANDA

BY

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DECLARATION

I OTAKOL JAMES, declare that this research report has never been presented to any institution of higher learning here or abroad for an academic award and the work contained in it is original unless otherwise declared.

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This project report has been submitted for examination with the approval of the following supervisor:

………pmusagala………

Mr. Musagala Peter

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ABSTRACT

The purpose of this study was to assess the level of nutrient pollutants in Nagongera water stream. Specifically it was to determine the total concentration of Nitrogen and Phosphorus and to establish the level of water pollution by Nitrogen and Phosphorus in Nagongera water stream. The samples were obtained from Nagongera stream and were collected using bottles. The samples of water from different sites were analyzed using A JEN WAY Geneva plus Model 6705 UV-Visible Spectrophotometer set at a wave length of 890nm. This was first zeroed by use of blank solution in a cuvette (1cm) thick, followed by the standards of concentrations 1mg/l, 2mg/l, 3mg/l, 4mg/l, 5mg/l and 10mg/l in order to calibrate the instrument. The study found out that the concentration of Nitrogen and that of Phosphorus were below as compared to their standards which therefore showed the level of water pollution by Nitrogen and Phosphorus were below their standard concentration. The study concluded that water in Nagongera is not suitable for consumption because of high concentration of phosphorus in site 2. Due to this, there is need for policy makers and other stake holders to regulate the nutrient pollution in Nagongera stream by restricting direct drainage of detergents containing effluents from residential and commercial settings.

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LIST OF ABBREVIATIONS AND ACRONYMS

UV-Vis near IR – Ultra-Violet visible near Infrared

TN- Total Nitrogen

TP- Total Phosphorous

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Water pollution is a global challenge that has increased both in developed and developing countries, undermining the economic growth as well as physical and environmental health of billions of people. Although global attention has focused primarily on water quantity, water use efficiency and allocation issues, poor waste water management has created a serious water quality problem in many parts of the world, worsening the water crisis. Global water scarcity is caused by not only by physical scarcity of the resource but also by the progressive deterioration of water quality in many countries, reducing the quantity of water that is safe to use. The 2030 agenda for sustainable development acknowledges the importance of water quality and includes specific water quality target in sustainable development goal. this agenda is strongly expected to influence future policies and strategies and to ensure that the control of water pollution is elevated in international and national priorities.

Human settlements, industries and agriculture are the major sources of water pollution. globally , 80 percent of municipal waste water is discharged into the water bodies untreated, and industries responsible for dumping millions of tones of heavy metals, solvents , toxic sludge and other wastes into water bodies each year(wwap,2017).

Reactive nitrogen production has increased more than 20 times from 1860 to 2005 and currently amounts to about 187 tons annually, around 1.5 to 2 times the natural rate for the planet as a whole. Estimates suggest that some 90 tons of this reactive nitrogen derived from land based human activities ends up in the world’s oceans. of the around 20 million tons of phosphorus mined each year, nearly half is estimated to enter the world’s oceans which is 8 times the natural rate of input (european commission, 2014).

Nationally lake victoria is undergoing biodiversity, physical and chemical degradation compared to its status about four decades ago when Talling (1966) made his observations (ochumba et al.

1989; hecky 1993; muggide; 1993). Although it is reorganized by the scientific community that the lake is enriched with nutrients, there are conflicting reports on the magnitude of nutrients received from different sources and the dynamics of the nutrients in the lake. One school of thought considers that the lake has become a eutrophic ecosystem. this status is illustrated by proliferation algal blooms and the water hyacinth, native fish species disappearance, deoxygenation of deep waters this causes low levels of dissolved oxygen and decay of the sea grass hence death of aquatic life and the water becomes un fit for human consumption as a result og decay of algae.

in Nagongera water stream, phosphates which are compounds containing phosphorus enter waterways from human and animal waste, phosphorus-rich bedrock, laundry and cleaning wastewater, industrial effluents, and fertilizer runoff. These phosphates become detrimental when they over-fertilize aquatic plants and increase the rate of natural eutrophication, which is sometimes called cultural eutrophication or accelerated eutrophication.

The major impact of nitrates and phosphates on fresh water bodies is that of eutrophication. Nitrogen and phosphorous stimulate the growth of algae and other plankton which provide food for higher organisms (invertebrates and fish); however, an excess of nitrogen can cause over-production of plankton a phenomenon termed as nutrient pollution. Nutrient pollution can lead to excessive growth of algae and other aquatic plants (dodds*et al.*, 2009)

Surface water eutrophication due to excessive nutrients has indeed been registered a major environmental problem around the world in the past few decades. Among these nutrients, nitrogen and phosphorus are two of the most important harmful cyanobacterial bloom (hcb) drivers. Human-induced eutrophication degrades freshwater systems worldwide by reducing water quality and altering ecosystem structure and function (paerl*et al.*, 2001).

1.2 Statement of the problem

Nutrients pollutants such as waste water from treatment facilities, runoff from the town during rains, car and motor cycle washing, fertilizers from farms within the vicinity of the stream and other related activities all discharge their effluents into the Nagongera stream. Yet the excessive amounts of such nutrients can lead to more serious problems such as low levels of oxygen dissolved in the water, severe algal growth which blocks light that is needed for aquatic life and when these algae, liliesand water cabbage die, they decay, in the process, the oxygen in the water is used up and this leads to low levels of dissolved oxygen in the water. This in turn, can kill fish, crabs and other aquatic animals. The bad scent in water paired with the resulting water color due to algal decay makes it non fit for consumption and domestic use.Nitrogen and phosphorus are essential nutritional elements for life processes in water bodies. However, in excessive quantities they may represent a significant source of aquatic pollution (Longzhu et al. 2020). Therefore, this study sought to examine the concentration of nutrient pollutants in Nagongera water stream.

1.3 Objectives of the Study

The overall objective was to assess thelevel of nutrient pollutants in the Nagongera water stream.

The overall object will be achieved by the following specific objectives;

I. To determine the concentration of total Nitrogen in water samples from Nagongera water stream.

II. To determine the concentration of total Phosphorous in water samples from Nagongera water stream.

III. To establish the level of water pollution by Nitrogen and Phosphorus in Nagongera stream.

1.5 Justification of the study

Human related activities such as agriculture, car washing, laundry,commercial and residential, treatment of waste waters within the vicinity of Nagongerastream discharge their effluents into Nagongera stream. This may become disastrous to human health especially those who use it for home consumption.It could pause a possible threat to the aquatic environment of nutrient pollution thus eutrophication especially if excessive amounts of nitrogen and phosphorous input into the stream by outstated activities above. Therefore, there was a need to assess the nutrient pollutants' content in Nagongera stream especially nitrogen and phosphorous to create awareness to the general public about nutrient pollution, presumed sources of the nutrients to water streams or bodies and resulting negative effects of the same on the environment. The availed information could be used in the conservation of water streams and generally water bodies from nutrient pollution.

Shall provide information to policy makers, local leaders and other concerned stakeholders about the environmental issue at hand and these shall therefore be in a better position to make informed decisions in future.

1.5 Literature Review

1.5.1 Occurrence and distribution of Nitrogen

Among the elements, nitrogen ranks sixth in cosmic abundance. The atmosphere of Earth consists of 75.51 percent by weight (or 78.09 percent by volume) of nitrogen; this is the principal source of nitrogen for commerce and industry. The atmosphere also contains varying small amounts of ammonia and ammonium salts, as well as nitrogen oxides and nitric acid (the latter substances being formed in electrical storms and in the internal combustion engine). Free nitrogen is found in many meteorites; in gases of volcanoes, mines, and some mineral springs; in the Sun; and in some stars and nebulae.

Nitrogen also occurs in mineral deposits of nitrate or saltpetre (potassium nitrate, KNO_3) and Chile saltpetre (sodium nitrate, $NaNO_3$), but these deposits exist in quantities that are wholly inadequate for human needs. Another material rich in nitrogen is guano, found in bat caves and in dry places frequented by birds. In combination, nitrogen is found in the rain and soil as ammonia and ammonium salts and in seawater as ammonium (NH_4^+), nitrite (NO_2^-), and nitrate (NO_3^-) ions. Nitrogen constitutes on the average about 16 percent by weight of the complex organic compounds known as proteins, present in all living organisms. The natural abundance of nitrogen in Earth's crust is 0.3 part per 1,000. The cosmic abundancethe estimated total abundance in the universeis between three and seven atoms per atom of silicon, which is taken as the standard (Sanderson, 2020).

1.5.2 Occurrence and distribution of Phosphorous

Phosphorusis a very widely distributed element,12th most abundant in the Earth's crust to which it contributes about 0.10 weight percent (Britannica, 2021). Its cosmic abundance is about one atom per 100 atoms of silicon, the standard. Its high chemical reactivity assures that it does not occur in the Free State (except in a few meteorites). Phosphorus always occurs as the phosphate ion. The principal combined forms in nature are the phosphate salts. About 550 different minerals have been found to contain phosphorus, but, of these, the principal source of phosphorus is the apatite series in which calcium ions exist along with phosphate ions and variable amounts of fluoride, chloride, or hydroxide ions, according to the formula [$Ca_{10}(PO_4)_6$(F, Cl, or $OH)_2$]. Other important phosphorus-bearing minerals are wavellite and vivianite. Commonly, such metal atoms as magnesium, manganese, strontium, and lead substitute for calcium in the mineral, and silicate, sulfate, vanadate, and similar anions substitute for phosphate ions. Very large sedimentary deposits of fluoroapatite are found in many parts of the Earth. The phosphate of bone and tooth enamel is hydroxyapatite. (The principle of lessening tooth decay by fluoridation depends upon the conversion of hydroxyapatite to the harder, more decay-resistant, fluoroapatite.)

The chief commercial source is phosphorite, or phosphate rock, an impure massive form of carbonate-bearing apatite. Estimates of the total phosphate rock in Earth's crust average about 65,000,000,000 tons, of which Morocco and Western Sahara contain about 80 percent. This estimate includes only ore that is sufficiently rich in phosphate for conversion to useful products by present methods. Vast quantities of material lower in phosphorus content also exist (Sanderson, 2020).

The only naturally occurring isotope of phosphorus is that of mass 31. The other isotopes from mass 24 to mass 46 have been synthesized by appropriate nuclear reactions. All of these are radioactive with relatively short half-lives. The isotope of mass 32 has a half-life of 14.268

days and has proven extremely useful in tracer studies involving the absorption and movement of phosphorus in living organisms (Augustyn, 2020)

1.5.3 Commercial production and uses of Nitrogen

Commercial production of nitrogen is largely by fractional distillation of liquefied air. The boiling temperature of nitrogen is −195.8 °C (−320.4 °F), about 13 °C (−23 °F) below that of oxygen, which is therefore left behind. Nitrogen can also be produced on a large scale by burning carbon or hydrocarbons in air and separating the resulting carbon dioxide and water from the residual nitrogen. On a small scale, pure nitrogen is made by heating barium azide, $Ba(N_3)_2$. Various laboratory reactions that yield nitrogen include heating ammonium nitrite (NH_4NO_2) solutions, oxidation of ammonia by bromine water, and oxidation of ammonia by hot cupric oxide(Sanderson, 2020).

Elemental nitrogen can be used as an inert atmosphere for reactions requiring the exclusion of oxygen and moisture. In the liquid state, nitrogen has valuable cryogenic applications; except for the gases hydrogen, methane, carbon monoxide, fluorine, and oxygen, practically all chemical substances have negligible vapour pressures at the boiling point of nitrogen and exist, therefore, as crystalline solids at that temperature.

In the chemical industry, nitrogen is used as a preventive of oxidation or other deterioration of a product, as an inert diluent of a reactive gas, as a carrier to remove heat or chemicals and as an inhibitor of fire or explosions. In the food industry nitrogen gas is employed to prevent spoilage through oxidation, mold, or insects, and liquid nitrogen is used for freeze drying and for refrigeration systems. In the electrical industry nitrogen is used to prevent oxidation and other chemical reactions, to pressurize cable jackets, and to shield motors. Nitrogen finds application in the metals industry in welding, soldering, and brazing, where it helps prevent oxidation, carburization, and decarburization (Herring, 2016). As a nonreactive gas, nitrogen is employed to make foamed or expanded rubber, plastics, and elastomers, to serve as a propellant gas for aerosol cans, and to pressurize liquid propellants for reaction jets. In medicine rapid freezing with liquid nitrogen may be used to preserve blood, bone marrow, tissue, bacteria, and semen. Liquid nitrogen has also proven useful in cryogenic research (Sanderson, 2020).

1.5.4 Commercial production and uses of Phosphorous

The principal technique for converting phosphate rock to usable materials involves acidulation of the crushed rockwitheither sulfuric or phosphoric acids form crude calcium hydrogen phosphates that, being water-soluble, are valuable additions to fertilizer. Most of the output is burned to phosphoric anhydride and subsequently treated with water to form phosphoric acid, H_3PO_4. About 95 percent of the phosphate rock mined in the United States is used to make fertilizer or food supplements for animals. Concerns have arisen about phosphorus use, however. Most of the phosphorus is wasted on its journey from mining to being eaten by humans, and the wasted phosphorus ends up in waterways where it can cause algal blooms. Another concern is that increased phosphorus usage will deplete the nonrenewable supply of phosphate rock (Encyclopedia Britannica, 2021).Only about 5 percent of the phosphorus consumed per year in the United States is used in the elemental form (Encyclopedia Britannica, 2021). Pyrotechnic applications of the element include; tracers, incendiaries, fireworks, and matches. Some is used as an alloying agent, some is used to kill rodents, and the rest is employed in chemical synthesis (Steven, 2008). A large amount is converted to sulfides used in matches and in the manufacture of insecticides and oil additives. Most of the remainder is converted to halides or oxides for subsequent use in synthesizing organic phosphorus compounds (James *et al*., 2016)

1.5.5 Compounds of Nitrogen

Although the other applications are important, by far the greatest bulk of elemental nitrogen is consumed in the manufacture of nitrogen compounds. The triple bond between atoms in the nitrogen molecules is so strong (226 kilocalories per mole, more than twice that of molecular hydrogen) that it is difficult to cause molecular nitrogen to enter into other combinations. (Sanderson, 2020)

The chief commercial method of fixing nitrogen (incorporating elemental nitrogen into compounds) is the Haber-Bosch process for synthesizing ammonia. This process was developed during World War I to lessen the dependence of Germany on Chilean nitrate. It involves the direct synthesis of ammonia from its elements. (Sanderson,2020)

Large quantities of nitrogen are used together with hydrogen to produce ammonia, NH_3, a colorless gas with a pungent, irritating odor. The chief commercial method of synthesizing ammonia is the Haber-Bosch process (Haber, 1918). Ammonia is one of the two principal nitrogen compounds of commerce; it has numerous uses in the manufacture of other important nitrogen compounds. A large portion of commercially synthesized ammonia is converted into nitric acid (HNO_3) and nitrates, which are the salts and esters of nitric acid. Ammonia is used in the ammonia-soda process (Solvay process) to produce soda ash, Na_2CO_3. Ammonia is also used in the preparation of hydrazine, N_2H_4, a colorless liquid used as a rocket fuel and in many industrial processes (Chemical safety facts, 2019).

Nitric acid is another popular commercial compound of nitrogen. A colorless, highly corrosive liquid, it is much used in the production of fertilizers, dyes, drugs, and explosives. Urea (CH_4N_2O) is the most common source of nitrogen in fertilizers. Ammonium nitrate (NH_4NO_3), a salt of ammonia and nitric acid, is also used as a nitrogenous component of artificial fertilizers and, combined with fuel oil, as an explosive (ANFO) (Encyclopedia of analytical science, 2017)

With oxygen, nitrogen forms several oxides, including nitrous oxide, N_2O, in which nitrogen is in the +1-oxidation state; nitric oxide, NO, in which it is in the +2 state; and nitrogen dioxide, NO_2, in which it is in the +4 state. Many of the nitrogen oxides are extremely volatile; they are prime sources of pollution in the atmosphere. Nitrous oxide, also known as laughing gas, is sometimes used as an anesthetic; when inhaled it produces mild hysteria. Nitric oxide reacts rapidly with oxygen to form brown nitrogen dioxide, an intermediate in the manufacture of nitric acid and a powerful oxidizing agent utilized in chemical processes and rocket fuels (Jeff *et al*., 2017).

Also, of some importance are certain nitrides, solids formed by direct combination of metals with nitrogen, usually at elevated temperatures. They include hardening agents produced when alloy steels are heated in an atmosphere of ammonia, a process called nitriding. Those of boron, titanium, zirconium, and tantalum have special applications. One crystalline form of boron nitride (BN), for example, is nearly as hard as diamond and less easily oxidized and so is useful as a high-temperature abrasive (Steven *et al*., 2008)

The inorganic cyanides contain the group CN^-. Hydrogen cyanide, or formonitrile, HCN, is a highly volatile and extremely poisonous gas that is used in fumigation, ore concentration, and various other industrial processes. Cyanogen, or oxalonitrile, $(CN)_2$, is also used as a chemical intermediate and a fumigant.

Azides, which may be either inorganic or organic, are compounds that contain three nitrogen atoms as a group, represented as ($—N_3$). Most azides are unstable and highly sensitive to shock. Some of them, such as lead azide, $Pb(N_3)_2$, are used in detonators and percussion caps. The azides, like the halogen compounds, readily react with other substances by displacement of the so-called azide group and yield many kinds of compounds (Zimmerman *et al*., 2005)

Nitrogen forms many thousands of organic compounds. Most of the known varieties may be regarded as derived from ammonia, hydrogen cyanide, cyanogen, and nitrous or nitric acid (Jorgensen, 2020). The amines, amino acids, and amides, for example, are derived from or closely related to ammonia. Nitroglycerin and nitrocellulose are esters of nitric acid. Nitro compounds are obtained from the reaction (called nitration) between nitric acid and an organic compound. Nitrites are derived from nitrous acid (HNO_2). Nitroso compounds are obtained by the action of nitrous acid on an organic compound. Purines and alkaloids are heterocyclic compounds in which nitrogen replaces one or more carbon atoms.

1.5.6Compounds of Phosphorous

Phosphorus is used almost entirely in the form of compounds, usually in the oxidation states of +3, +5, and −3. Unlike nitrogen and various other members of the family, phosphorus tends to exhibit a preference for the +5 state.

Of considerable economic significance is phosphine, or hydrogen phosphide, PH_3. This gaseous compound is produced either by the action of a strong base (or hot water) on white phosphorus or by the hydrolysis of a metal phosphide. Phosphine is used mainly as a starting material in the synthesis of various organic phosphorus compounds, as a doping agent for solid-state electronics components, and as a fumigant.

1.5.7 Properties and reactions of Nitrogen

Nitrogen is a colorless, odorless gas, which condenses at −195.8 °C to a colorless, mobile liquid. The element exists as N_2 molecules, represented as: N:::N: for which the bond energy of 226 kilocalories per mole is exceeded only by that of carbon monoxide, 256 kilocalories per mole. Because of this high bond energy, the activation energy for reaction of molecular nitrogen is usually very high, causing nitrogen to be relatively inert to most reagents under ordinary conditions. Furthermore, the high stability of the nitrogen molecule contributes significantly to the thermodynamic instability of many nitrogen compounds, in which the bonds, although reasonably strong, are far less than those in molecular nitrogen. For these reasons, elemental nitrogen appears to conceal quite effectively the truly reactive nature of its individual atoms (James *et al.*, 2016)

A relatively recent and unexpected discovery is that nitrogen molecules are able to serve as ligands in complexcoordination compounds. The observation that certain solutions of ruthenium complexes can absorb atmospheric nitrogen has led to hope that one day a simpler and better method of nitrogen fixation may be found (Augustyn*et al.*, 2020)

An active form of nitrogen, presumably containing free nitrogen atoms, can be created by passage of nitrogen gas at low pressure through a high-tension electrical discharge. The product glows with a yellow light and is much more reactive than ordinary molecular nitrogen, combining with atomic hydrogen and with sulfur, phosphorus, and various metals, and capable of decomposing nitric oxide, NO, to N_2 and O_2.

A nitrogen atom has the electronic structure represented by $1s^22s^22p^3$. The five outer shell electrons screen the nuclear charge quite poorly, with the result that the effective nuclear charge felt at the covalent radius distance is relatively high. Thus nitrogen atoms are relatively small in size and high in electronegativity, being intermediate between carbon and oxygen in both of these properties. The electronic configuration includes three half-filled outer orbitals, which give the atom the capacity to form three covalent bonds. The nitrogen atom should therefore be a very reactive species, combining with most other elements to form stable binary compounds, especially when the other element is sufficiently different in electronegativity to impart substantial polarity to the bonds. When the other element is lower in electronegativity than nitrogen, the polarity gives partial negative charge to the nitrogen atom, making its lone-pair electrons available for coordination. When the other element is more electronegative, however, the resulting partial positive charge on nitrogen greatly limits the donor properties of the molecule. When the bond polarity is low (owing to the electronegativity of the other element being similar to that of nitrogen), multiple bonding is greatly favored over single bonding. If disparity of atomic size prevents such multiple bonding, then the single bond that forms is likely to be relatively weak, and the compound is likely to be unstable with respect to the free elements. All of these bonding characteristics of nitrogen are observable in its general chemistry (Melanie *et al*., 2022).

1.5.8Properties and reactions of Phosphorous

The electron configuration of the phosphorus atom can be represented by $1s^2 2s^2 2p^6 3s^2 3p^3$. The outer shell arrangement therefore resembles that of nitrogen, with three half-filled orbitals each capable of forming a single covalent bond and an additional lone-pair of electrons. Depending on the electronegativity of the elements with which it combines, phosphorus can therefore exhibit oxidation states of +3 or −3, just as does nitrogen. The principal differences between nitrogen and phosphorus are that the latter is of considerably lower electronegativity and has larger atoms, with outer *d* orbitals available. For these reasons, the similarities between nitrogen and phosphorus chemistry are largely formal ones, tending to conceal the actual, wide differences

(Zimmerman *et al*., 2008). The outer *d* orbitals in phosphorus permit an expansion of the octet, which leads to the +5 state, with five actual covalent bonds being formed in compounds, a condition impossible for nitrogen to achieve.

The first striking difference in chemistry of the two elements is that elemental phosphorus exists under ordinary conditions in any of 10 modifications, or allotropic forms, all of which are solid; the three major allotropes are white, red, and black. Phosphorus molecules of formula P_2, structurally analogous to N_2 molecules and evidently also triply bonded, exist only at very high temperatures. These P_2 molecules do not persist at lower temperaturesbelow about 1,200 °C (2,200 °F)because of the fact that three single bonds in phosphorus, in contrast to the situation with nitrogen, are energetically favored over one triple bond. On cooling, the triply bonded P_2 molecules condense to form tetrahedral P_4 molecules, in which each atom is joined to three others by single bonds. White phosphorus has two allotropes: the alpha form, which is stable at ordinary temperatures, has a cubic crystal structure; the beta form, which is stable below −78 °C (−108 °F), has a hexagonal crystal structure. Because of the relatively weak intermolecular attractions (van der Waals forces) between the separate P_4 molecules, the solid melts easily at 44.1 °C (111.4 °F) and boils at about 280 °C (536 °F). Formation of tetrahedra requires bond angles of 60° instead of the preferred 90°–109° angles, so that white phosphorus is a relatively unstable, or metastable, form. It changes spontaneously, but slowly, at temperatures around 200 °C (390 °F) or higher, to a polymeric form called “red phosphorus.” This substance is amorphous when formed at lower temperatures, but it can become crystalline, with a melting point of about 590° C (1,090 °F). At higher temperatures and pressures, or with the aid of a catalyst, at ordinary pressures and a temperature of about 200 °C, phosphorus is converted to a flaky black crystalline form, which somewhat resembles graphite. This may prove to be the most stable form of phosphorus, despite the relative difficulty in its preparation. In both the red and the black forms, each phosphorus atom forms three single bonds, which are spread apart sufficiently to be relatively strain free (Mahadevaiah*et al.*, 2011).

Consistent with the metastable condition of the white modification, and the crowding of its covalent bonds, this form is far more reactive chemically than the others. It is highly toxic, reacts vigorously with most reagents, and inflames in air at only 35° C (95 °F), so it must be stored under water or other inert liquid. White phosphorus dissolves readily in solvents such as carbon disulfide, in which it maintains the composition P_4. White phosphorus has been used for military purposes as a source of smoke and to fill incendiary shells and grenades. In contrast, red phosphorus is insoluble and relatively inert, although large quantities of the usual commercial form can ignite spontaneously in air and react with water to form phosphine and phosphorus oxyacids. Red phosphorus is used in preparing the striking surface for safety matches. Black phosphorus is more inert and is capable of conducting electricity. Both these polymeric forms are insoluble and are very much less volatile than white phosphorus (Steven *et al*., 2008)

1.5.9 Nitrogen and Phosphorous in aquatic environment

Nitrogen and phosphorous act as nutrients for growth of planktons, however, when much of these two is present in water bodies, it may have detrimental effect on the quality of surface water in the affected water bodies, and aquatic life may not be supported any more as well. Being of such an effect therefore efforts have been made to establish suitable concentration of Nitrogen and phosphorous respectively, in water bodies that may not have detrimental effects on the water environment.

Total Nitrogen (TN) concentrations in surface water have been classified in China and other countries to control water eutrophication and improve water quality. To identify at-risk surface water bodies and protect them from eutrophication, the USEPA developed guidelines, which state that Nitrogen concentrations should not exceed 0.3 mg/L in streams and rivers or 0.1 mg/L in lakes and reservoirs. Water has been divided into 14 distinct aggregate nutrient ecoregions in the U.S. according to total Phosphorous and total Nitrogen concentrations, chlorophyll *a* and turbidity (Environment Protection Agency, 2021). In China surface water has been divided into five categories according to the Chinese National Quality Standards for Surface Water. Water categorized as class I to III can be used as drinking water, while class IV and V water is only suitable for industrial and agricultural uses. The total N values for categories I – V are < 0.2 mg/L, 0.2 – 0.5 mg/L, 0.5 – 1.0 mg/L, 1.0 – 1.5 mg/L and 1.5 – 2.0 mg/L, respectively

In 1986, the Environmental Protection Agency (EPA) established the following recommended criteria for phosphorus: No more than 0.1 mg/L for streams that do not empty into reservoirs; no more than 0.05 mg/L for streams discharging into reservoirs; and no more than 0.024 mg/L for reservoirs.

In June of 1998 the U.S. Environmental Protection Agency issued a National Strategy for Development of Regional Nutrient Criteria to help states in developing nutrient water quality standards for lakes, reservoirs, rivers, streams, wetlands, estuaries, and coastal waters.

The European Commission took similar action which required member states to identify nitrate vulnerable zones (NVZs) and take steps to monitor, control, and reduce water pollution from excessive use of fertilizers. In characterizing the problem of nutrient pollution, the USEPA stated; “Cultural eutrophication (human-caused inputs of excess nutrients in water bodies) is one of the primary factors resulting in impairment of surface waters in the US.” Nutrient pollution reduction is a priority for USEPA regions because states have listed over 10,000 nutrient-related Clean Water Act Section 303 (d) impairments. Reduction of nutrient pollution levels requires monitoring and control of the major sources of excess nutrients. Point sources of nutrient discharge include municipal and industrial wastewater facilities, storm water runoff, and some large animal feed operations. Nutrients discharge from point sources are controlled through National Pollutant Discharge Elimination System (NPDES) permits. Nutrient discharge from nonpoint sources such as crop and livestock production, and storms are irregular and seasonal in nature. Several factors make monitoring of nutrient pollutants a challenging analytical task. The physicochemical properties of samples from water treatment facilities are considerably different than samples from lakes, rivers, wetlands and marine environments. The concentration of nutrients in samples from impaired and unimpaired water bodies can vary significantly. Nutrient levels can also fluctuate seasonally, and after storms. In some cases, (e.g.,pore water from marine sediments).

And therefore, established the following criteria for nutrient levels in respective water bodies; a range of 0.005 - 10 mg/L nitrates, 0.05 - 20 mg/L Total Nitrogen, 0.01 - 25 mg/L Ammonia, 50 ppm - 2,000 ppm Carbon – TOC, and 0.01 - 20 mg/L Total Phosphorus for drinking water and/or waste water whereas a range of 0.02 - 40 µmoles/L nitrates, 0.10 - 5.0 µmoles/L Ammonia, 0.5 - 10 ppm Carbon – TOC, and 0.02 - 10 µmoles/L Orthophosphates for sea water.

Phosphorous is most commonly found as orthophosphate (Chaube*et al*, 1983). Naturally, various forms of phosphorous such as ortho-, pyro-, poly-, meta-, organic, colloidal, and also suspended phosphorous are present in the water. Each of this phosphorous form can be measured as orthophosphate (Mihajlovic, et al., 2007).

Although phosphate is not toxic element, but the excessive concentration of phosphate in the natural water may cause detrimental effect to the aquatic life. An excess concentration of phosphate in the natural water may cause excessively grow of algae and aquatic plants and using up the large amount of oxygen, so the dissolved oxygen level in the water was decreased. According the Initial Global Aquaculture Alliance, the standard for total phosphorus was set at 0.5mg per litre, with a target standard of 0.3mg per litre. These concentrations are thought to be low enough to prevent eutrophication in rivers (Claude 2001). This condition is known as eutrophication. Eutrophication brings the detrimental effect for the aquatic life. To control the eutrophication process, EPA recommended the maximum concentration of phosphate is 50 and 100 μg/L in a stream point entering the natural water and in a stream point that is not directly entering the natural water, respectively.

One of the greatest phosphate contributors to the natural water is detergent. A synthetic detergent consists of a surfactant, builder and other miscellaneous ingredient (Ganesh, *et al*., 2012).

Total nitrogen (TN) includes all forms of nitrogen (organic and inorganic) that is found in the water, with the exception of the gas phase (N2), and is defined as the nitrogen that gives rise to nitrite/nitrate ions. In practice, TN is the sum of nitrite, nitrate, ammonia, and dissolved and particulate organic nitrogen (Mahadevaiah, et al., 2007). TN is an important variable to measure for keeping track of the nitrogen budget, and is commonly used for monitoring the state of the environment in lakes and the ocean, and also for monitoring waste streams and cultivations in aquatic environments. According to the United states public health service, it established that the specific standard of 10mg per litre of Nitrogen has a maximum concentration safe for human consumption (Gatiboni& Osmond 2019).

CHAPTER TWO

EXPERIMENTAL

2.1 Study area

The study is carried out on water samples obtained from Nagongera stream, Nagongera division, Tororo District, Eastern Uganda. Along the stream three target point were identified for sampling that is;

Site 1 (downstream), located at latitude N 2^{0}46’32.48112” and longitude E 32^{0}17’59.68284”, a point about 30 meters before the target contamination point of the water stream. It is chosen because not much human activities take place at this point of the stream therefore no or less human related inputs of nutrients into the stream and the aim is to establish the pre-contamination concentrations of the nutrients particularly nitrogen and phosphorous.

Site 2 (Mid-stream), located at Latitude N 2^{0}46’31.4256” and Longitude E 32^{0}17’51.47772”, a point where there is a number of human activities such car washing, agriculture and other commercial and residential laundry related activities that discharge waste waters directly in the Nagongera stream, this point is identified so as to assess the extent of nutrient pollution in Nagongera stream as result of human related activities.

Site 3 (Upstream), located at Latitude N 2^{0}46’30.64332” and Longitude E 32^{0}17’50.08632”, a point about 100 meters away from site 2. It is chosen to assess the post contamination nitrogen and phosphorous concentrations as a greater portion of the nutrients is presumed to be used up by the planktons and other aquatic plants

2.2 Preparation of reagents for Nitrogen analysis

Sodium hydroxide solution (10 M)was prepared by dissolving Sodium hydroxide (40 g) weighed on an electronic balance in distilled water (100 mL) volumetric flask filled to the mark.

Sodium salicylatewas prepared by dissolving sodium hydroxide (1 g) in distilled water (50 mL) in a 250 mL glass beaker and then added salicylic acid (3.5 g) to the sodium hydroxide solution in the beaker. The mixture was heated to boiling on a hot plate until all the salicylic acid dissolved during complete neutralization. The hot solution of sodium salicylatewas left to evaporate slowly until white crystals were formed weighed and stored in a clean, labeled chemical container.

Stock solution of N-NO_3wasprepared by dissolving Potassium nitrate (0.1631 g) weighed off a sample which had been dried in temperature 105°C for 24 hours in 1000 mL distilled water in a volumetric flask to make the stock solution.

Reference standards are prepared by dilution of portions of potassium nitrate stock solution (0.61 mL, 1.23 mL,1.84 ml, 2.45 mL,3.07 mL and 6.13 mL) to (1,2,3,4,5,10) mg/L, respectively with distilled water in 100 mL Volumetric flasks.

2.3 Preparation of reagents for Phosphorus analysis

A stock solution of phosphate (500 mg/L) was prepared by dissolving of 2.195 g potassium dihydrogen phosphate anhydrate into a glass beaker, then transferred into a 1000 mL volumetric flask and diluted with the distilled water to the mark. Subsequently, the series of phosphate working solution was prepared by further dilution of stock solution.

5 N Sulphuricacidwas prepared by dilution of concentrated sulfuric acid (70 mL, ≈ 36N) with distilled water in a 500 mL volumetric flask to the mark.

Ammonium molybdate solution wasprepared by dissolving Ammonium molydate (20 g) in distilled water (100 mL), then transferred to into 500 mL volumetric flask and diluted to the mark with distilled water.

The mixed solution was prepared by mixing Sulphuric acid (50 mL), ammonium molybdate solution (15 mL), and Potassium antimonyltartrate solution (35 mL).

Reference standards are prepared by dilution of the standard phosphate solution to solutions with concentrations (0.1, 0.2, 0.3, 0.4, 0.5, 0.7, 1.0, 1.25, and 1.5) ppm

2.4 Sample preparation

2.4.1 Nitrogen

Samples were acidified using 1N Hydrochloric acid to prevent interferences due to the absorption of either OH^- or CO_3^{2-} . The samples (10 ml) were mixed with freshly prepared sodium salicylate (1 mL, 0.5% water solutions), evaporated in an evaporating dish and cooled. Concentrated sulphuric acid(1 mL) was added so that the entire residue was dehumidified and allowed to stand for 10 minutes and then transferred to a 50 mL volumetric flask. Sodium hydroxide (7 mL) was added and after cooling to room temperature, the volume was made to 50 mL with distilled water. After 10 minutes, the yellow solution remained.

2.4.2 Phosphorous

Samples (50 mL) werepipetted into 250 mL glass beakers, phenolphthalein indicator (1 drop) was added and the solution turned pink, Sulphuric acid (5 N, few drops) were added until the pink color disappeared, subsequently mixed solution (8 mL) is added to each glass, solutions were kept at room temperature for 30 minutes.

2.5 Sample analysis

2.5.1. Nitrogen

A JEN WAY Geneva plus Model 6705 UV-Visible spectrophotometer set at a wave length of 420 nm was first zeroed by use of a blank solution in a cuvette (1 cm) thick, followed by the standards of concentrations 1 mg/L, 2 mg/L, 3 mg/L, 4 mg/L, 5 mg/L and 10 mg/L in order to calibrate the instrument. After calibration, the samples are analyzed and their absorbance recorded

2.5.2 Phosphorous

A JEN WAY Geneva plus Model 6705 UV-Visible spectrophotometer set at a wave length of 890 nm was first zeroed by use of a blank solution in a cuvette (1 cm) thick, followed by the standards of concentrations 0.1 mg/L, 0.2 mg/L, 0.3 mg/L, 0.4 mg/L, 0.5 mg/L, 0.1 mg/L, 1.25 mg/L and 1.5 mg/L in order to calibrate the instrument. After calibration, the samples are analyzed and their absorbance recorded

CHAPTER THREE

RESULTS AND DICUSSIONS

3.1 RESULTS

After calibration of the spectrophotometer, standard curves were obtained for both nitrogen and phosphorous using the standard potassium nitrate solution and standard disodium hydrogen phosphate solution, respectively, onto the obtained curves, a line of best fit with the equation

$y = mx+c$was drawn (see appendix for Calibration curves)

No table of figures entries found.

Table 3.1: Nitrogen and Phosphorous concentrations (mg/L) in water samples from the three sites along Nagongera Stream

Site	Nitrogen	Phosphorous
Site 1	1.556 ± 0.2802	0.12 ± 0.006245
Site 2	4.098 ± 0.1388	2.024± 0.1206
Site 3	3.280 ± 1.326	0.2157 ± 0.01358

Table 3.2: level of water pollution by Nitrogen and Phosphorus in the three sites along Nagongera stream

Site	**Nitrogen** ***(mg/L)***	**Relative Standard**	**Pollution level**	**Phosphorus** ***(mg/L)***	**Relative Standard**	**Pollution level**

		10mg/L			**0.3mg/L**	
Site 1	1.556 ± 0.2802	Below standard	NIL	0.12 ± 0.006245	Below standard	NIL
Site 2	4.098 ± 0.1388	Below standard	NIL	2.024± 0.1206	Above standard	HIGH
Site 3	3.280 ± 1.326	Below standard	NIL	0.2157 ± 0.01358	Below standard	NIL

3.2 DICUSSIONS

The results from table 3.1 indicate that;

Site 1 had mean concentrations of Nitrogen and Phosphorous of 1.556 ± 0.2802 mg/L and 0.12 ± 0.006245 mg/L, respectively. As compared to sites 2 and 3, the nutrients concentration at this point of the stream were relatively low a phenomenon heavily attributed to less human activities undertaken near the water stream at this point therefore no direct discharge of nutrient containing effluents into Nagongera stream. It's apparent therefore that the current nitrogen and phosphorous concentrations at this point are partly due to the (nitrogen and Phosphorous) natural cycles that keep the two within bounds. Earlier studies also stated that "both nitrogen and phosphorous have natural bio-geo cycles that include conversion between different inorganic and organic forms, solid and dissolved (and gaseous for nitrogen) phases that maintain their pre-industrial concentrations within certain natural bounds", (He *et al*., 2011). However, the slightly high nutrient content as compared to the accepted limits as stated by the United States Environment Protection Agency of not more than 0.3 mg/L of nitrogen and less than 0.1 mg/L of

Phosphorous could be due geographical differences as well as surface runoff into Nagongera stream during rains.

Site 2 had mean nitrogen and phosphorous concentrations of 4.098 ± 0.1388 mg/L and 2.024 ± 0.1206 mg/L, respectively. The concentrations of nitrogen and phosphorous are therefore highest at this point of the stream because there is direct entry of waste waters from a car washing bay, septic systems, animal feed lots, agricultural fertilizer runoffs, laundry and cleaning waters and garbage. In agreement with the Pollution Control Agency (2008) the common sources of excess nitrate and phosphates reaching lakes and streams include septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dumps. Site 3 had nitrogen and phosphorous concentrations of 3.28 ± 0.1326 mg/L and 0.2157 ± 0.01358 mg/L, respectively. The concentration of nutrients here was lower than that at site 2 whereas almost double of that at site 1, this could be due to water flow that tends to distribute the chemical composition across the entire water mass but also the reduction in nutrient concentrations could be due to growing water vegetation immediately after site 2 which use these nutrients. According to earlier studies by Dodds*et al*., (2009), nutrient pollution can lead to excessive growth of algae and other aquatic plants.

Site 1 and 3 had low concentration of both Nitrogen and Phosphorus of 1.556 ± 0.2802 mg/L and 0.12 ± 0.006245 mg/L, respectively as compared to site 2 that had high concentration of Phosphorus2.024± 0.1206 which is heavily attributed to high human activities such excessive use of fertilizers etc that discharge effluents to the river.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The water from Nagongera stream is not suitable for human consumption, it can cause health related issues to humans once consumed. However, it can be used for industrial and agricultural purposes. As recommended by the Chinese National Quality Standards for Surface Water report in 2019 which categorized water as class I to III can be used as drinking water, while class IV and V water only suitable for industrial and agricultural uses. The total Nitrogen values for categories I – V are < 0.2 mg/L, 0.2 – 0.5 mg/L, 0.5 – 1.0 mg/L, 1.0 – 1.5 mg/L and 1.5 – 2.0 mg/L, respectively.

Human activities such as car washing, laundry and cleaning, water treatment, agriculture and garbage dumping with in the vicinity of Nagongera stream contribute the greatest percentage of nutrients to the stream thus nutrient pollution. High concentrations of nutrients such as nitrogen and phosphorous are primarily responsible for eutrophication and low water quality in Nagongera stream.

Some sites in Nagongera water stream contain high concentration of Phosphorus as compared to the set standard making the water unsuitable for home consumption.

4.2 RECOMMENDATIONS

Due to high nitrogen and phosphorous concentrations at some points of Nagongera stream, there is need for Policy makers and other stake holders to come up with a consensus that regulates nutrient pollution in Nagongera stream by restricting direct drainage of detergent containing waters, effluents from residential and commercial settings into Nagongera stream so as to keep nutrient levels within recommended limits.

The general public should adopt appropriate means and alternative sites for disposing of garbage and effluents other than the stream as this pauses a threat to aquatic life and lowers water quality.

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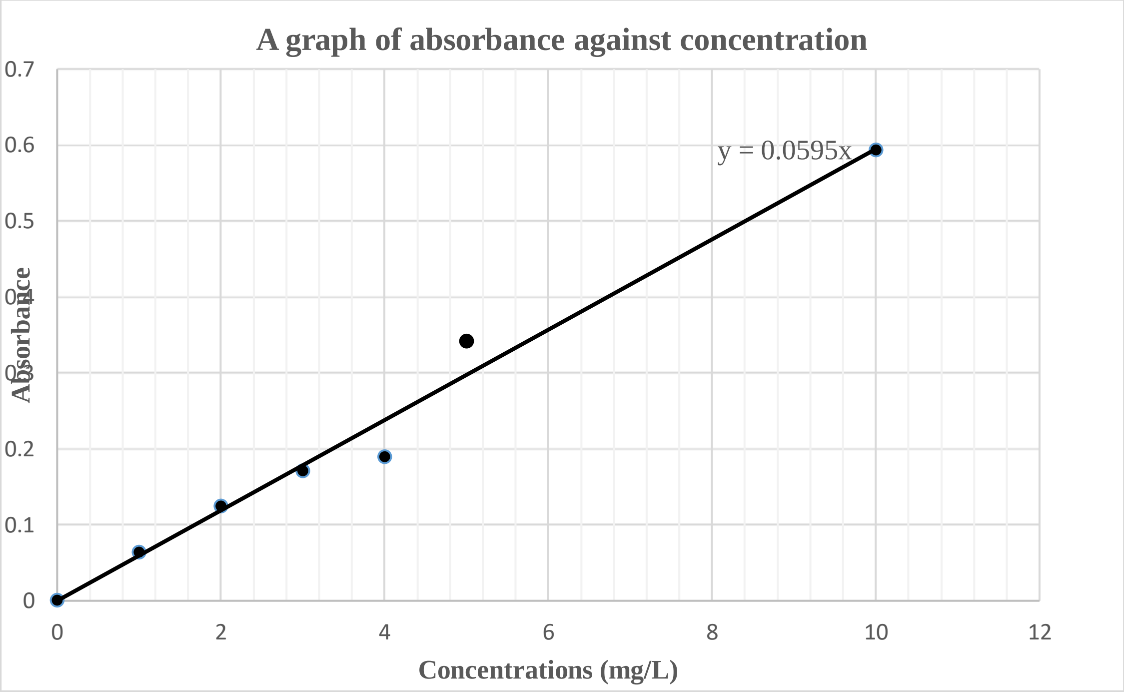
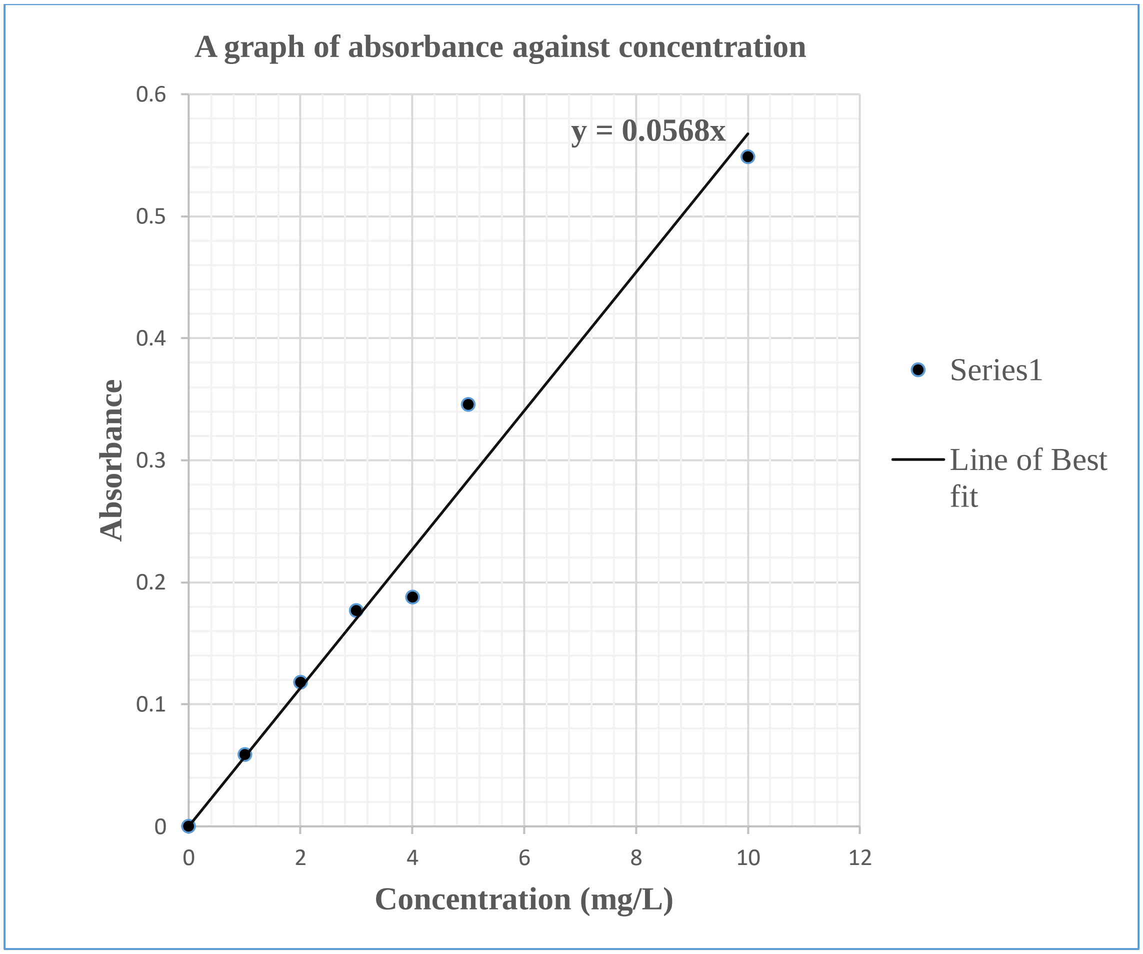
APPENDICES

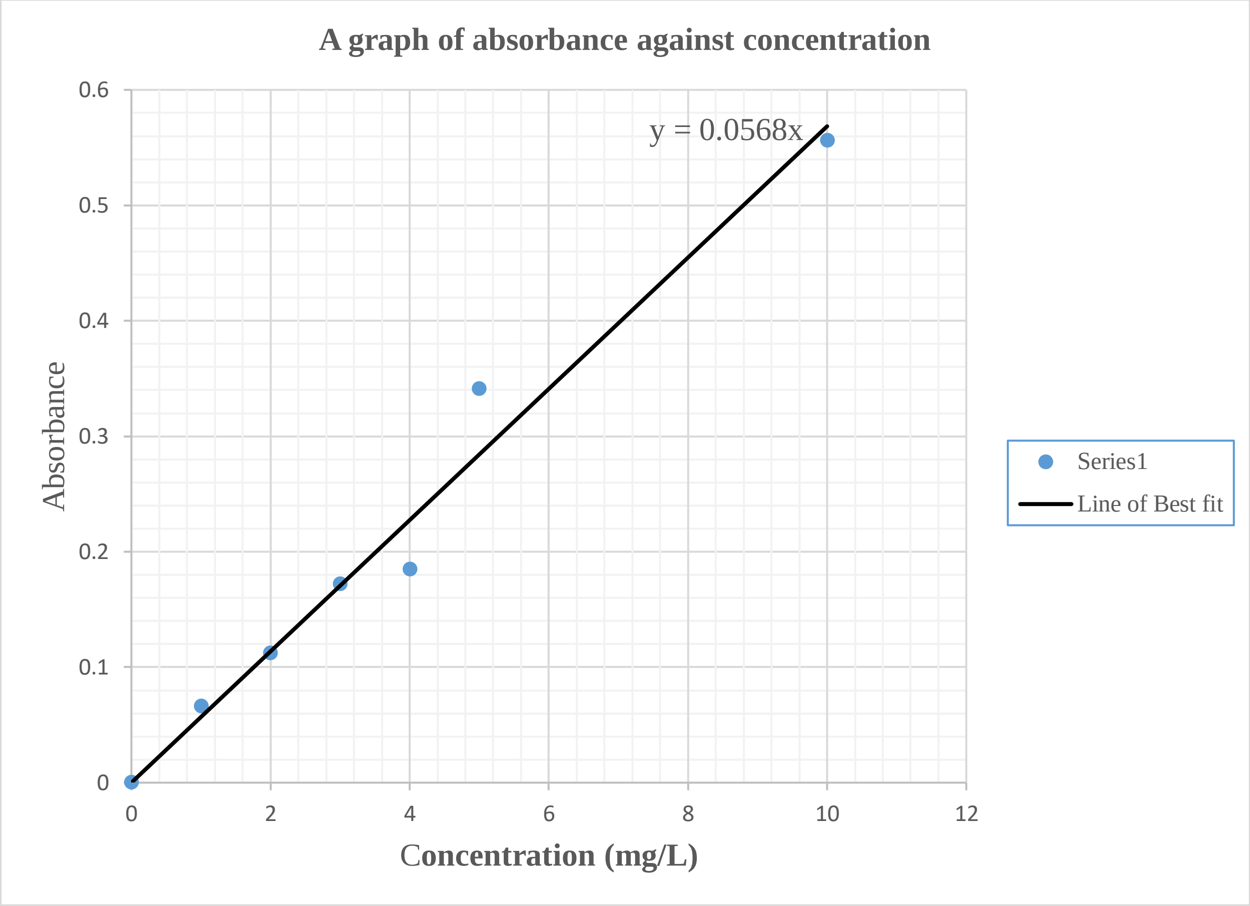
APPENDIX I: Calibration curve obtained using reference standards of Potassium nitrate solution- Experiment 1


A graph of absorbance against concentration
y = 0.0595x
Absorbance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
2
4
6
8
10
12
Concentrations (mg/L)

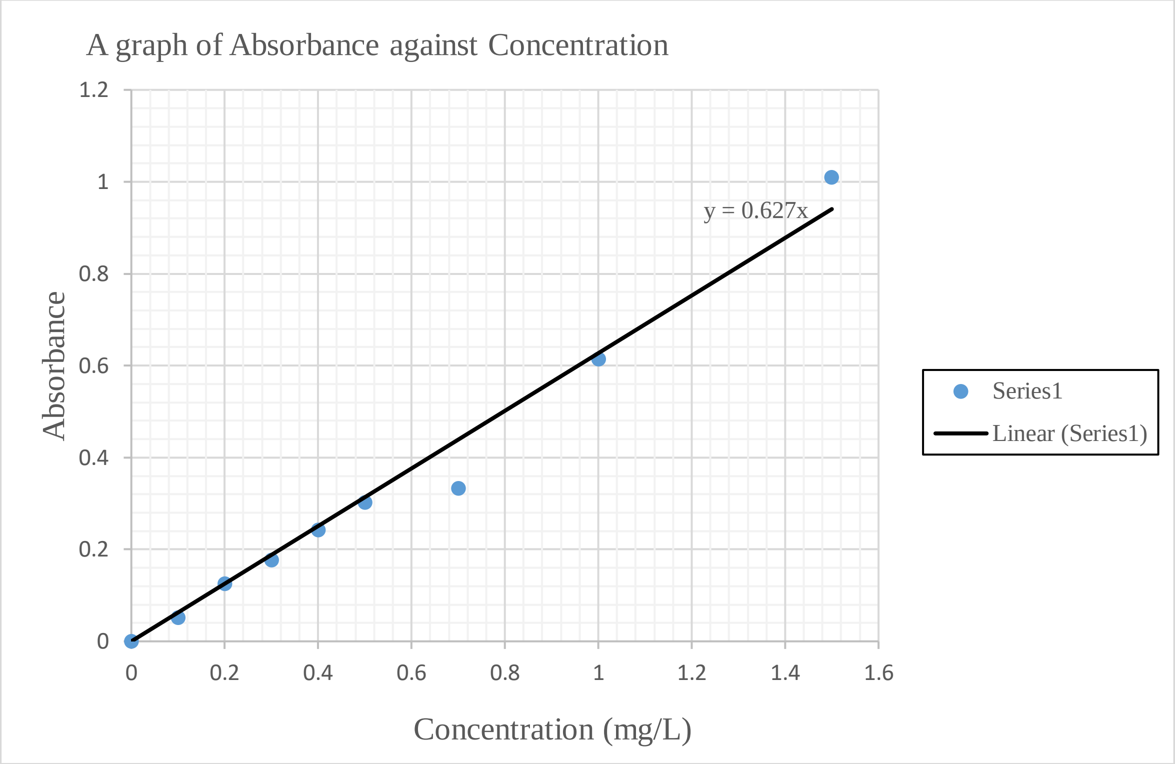
APPENDIX II: Calibration curve obtained using reference standards of Potassium nitrate solution- Experiment 2



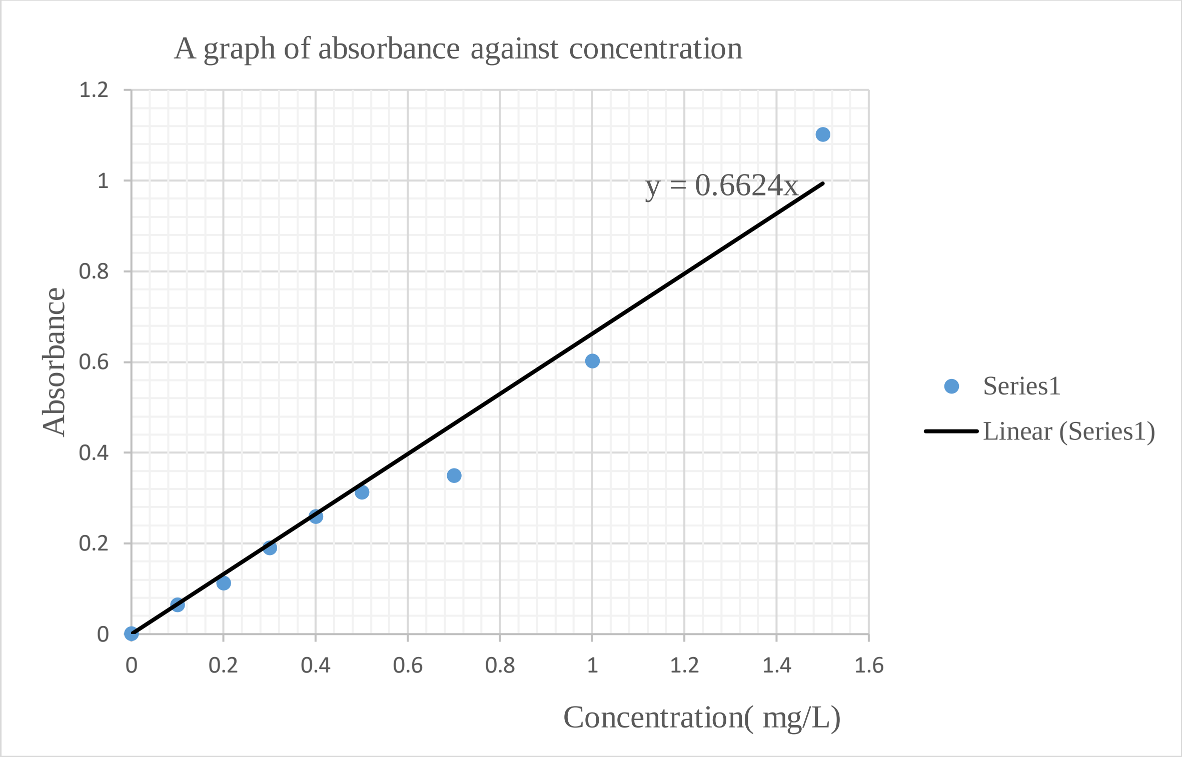
APPENDIX III: Calibration curve obtained using reference standards of Potassium nitrate solution- Experiment 3



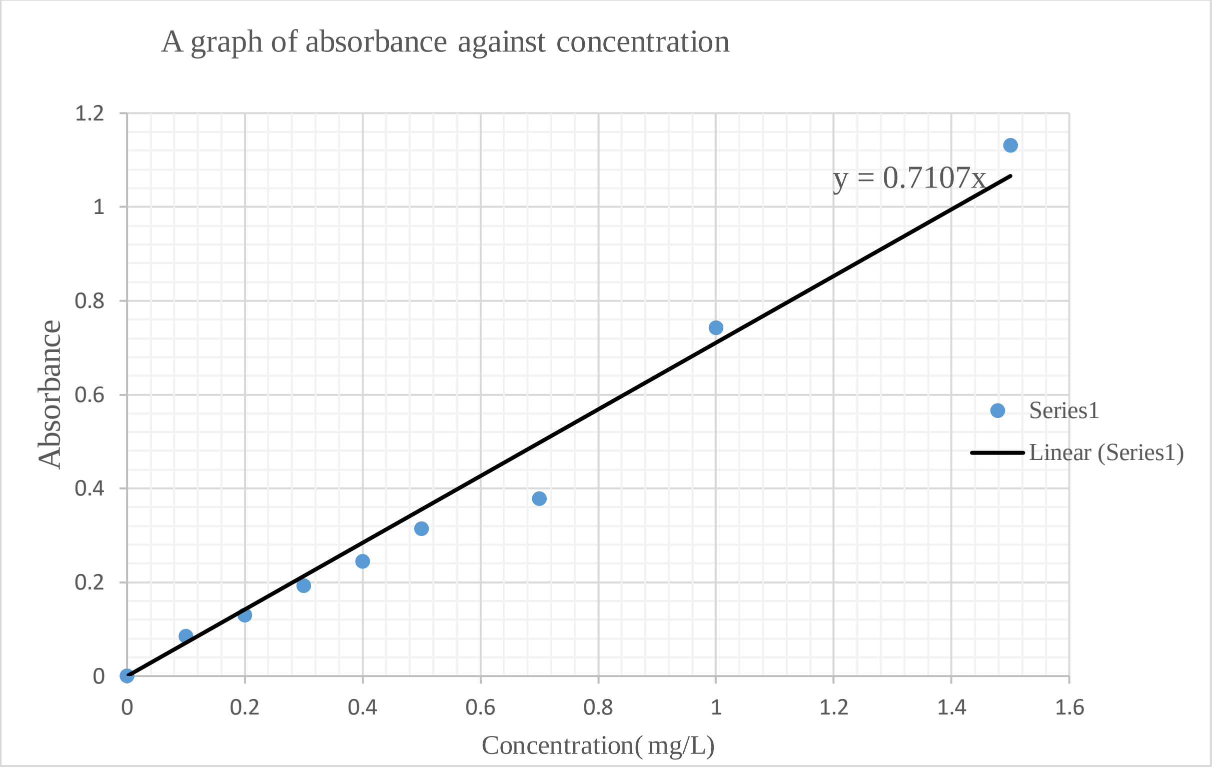
APPENDIX IV: Calibration curve obtained using reference standards of Disodium hydrogen phosphate solution- Experiment 1



APPENDIX V: Calibration curve obtained using reference standards of Disodium hydrogen phosphate solution- Experiment 2



APPENDIX VI: Calibration curve obtained using reference standards of Disodium hydrogen phosphate solution- Experiment 3


A graph of absorbance against concentration
y = 0.7107x
Absorbance
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Concentration(mg/L)
Series1
Linear (Series1)