Science and Technology
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Environmental Assessment for Water Quality of the White Nile River in Khartoum State

(A Cause Study of Aldabasin Area)

التـقـييـم البـيئـي لجـودة مـياه النـيل الأبيـض فـي ولايــة الخـرطـوم

(دراسـة حـالــة منـطقة الدباسـين)

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By

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الإستهلال .....

بسم الله الرحمن الرحيم

قال تعالى:

(وَهُوَ ٱلَّذِيٓ أَرۡسَلَ ٱلرِّيَٰحَ بُشۡرَۢا بَيۡنَ يَدَيۡ رَحۡمَتِهِۦۚ وَأَنزَلۡنَا مِنَ ٱلسَّمَآءِ مَآءٗ طَهُورٗا (48)لِّنُحۡـِۧيَ بِهِۦ بَلۡدَةٗ مَّيۡتٗا وَنُسۡقِيَهُۥ مِمَّا خَلَقۡنَآ أَنۡعَٰمٗا وَأَنَاسِيَّ كَثِيرٗا(49)

صدق الله العظيم

سورة الفرقان

Dedication

To My.......

Parents

Brothers

Sisters

Family

and Friends

For Being the Pillows, Role Models,
Cheerleading Squad and Sounding Boards
I have Needed.

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I must thank Almighty Allah for blessing me and helping me with everything I needed throughout my study of the Master program in very important thing: water. as Subhanho wtalla said in the Holy Quran (Al-anbiaa 30): “we made from water every living thing”.

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Abstract

The aim of this study was to assess the environmental quality of the White Nile water and identify pollution sources in Khartoum state (Aldabasin area was taken as a case study) because the area is located by many factories, sewage treatment plants and service institutions, after investigation and follow-up to find out the sources of pollution of the Nile in this area, it was found that there is drain system in this area directly drain into the Nile. The drain system consists of the joining of two drains sources: Soba Sewage Treatment Plant then the treated waste water of soba passing Elyarmouk military complex and the other drain is Rainwater in this area , Although it was noted that some physical characteristics such as the color and smell of this water showed that it is undoubtedly the drain system is the main cause of the pollution . but to achieve this goal and make sure ,water samples were taken from different points, the first water sample was taken before the treatment in Soba sewage treatment plant and the second sample after the treatment, the third sample was taken from the drain system immediately after water treated in Soba treatment plant and then passed Elyarmouk military complex. While the fourth sample was taken from the White Nile at the distance 13 meters after the waste water entering to the river. The physical characteristics (temperature, hydrogen number and connectivity) were measured and analyzed for all these points , the result showed that all these physical characteristics are within the acceptable and permitted limit as defined by the Sudanese Authority for Specifications and Standards for Liquid waste after treatment as well as specifications specified by the World Health Organization , Chemical tests were also conducted for the same samples, (Total suspended solids, Total dissolved solids salts, biological oxygen demand, chemical oxygen demand and heavy metals) and the results showed that all samples exceeded the ratios set by the Sudanese Authority for Specifications and Standards for Liquid waste after treatment as well as specifications specified by the World Health Organization, that means :

- Contamination of the White Nile water with sewage water, which was clearly reflected in the results of the biological oxygen demand and chemical oxygen demand by the analysis of the sample taken from the Nile, the results were (315-512 mg/l) respectively, while the allowable limit was (15-75 mg/l) respectively.

- Contamination of white Nile water with industrial wastewater, which is explained by the increasing of lead and cadmium metal in the Nile water where it was found for the same sample (0.21-0.0052 mg/l)respectively while the allowable limit (0.1-0.003mg/l) respectively.

So the main sources of Nile water pollution are:

- Soba sewage plant, which explained by the results of the analysis of samples before and after treatment, where it was noted that the biological oxygen demand was (290-270 mg/l) for samples before and after treatment respectively and chemical oxygen demand was (560-554 mg/l) respectively.

-Elyarmouk military complex, which is explained by the increasing of heavy metals in the drain system after the water treated in soba and passing Elyarmouk military complex where the result of lead and cadmium for the samples was (0.16-0.007mg/l) respectively and for samples after treatment at Soba station (0.004-0.02mg/l) respectively.

المستخلص

الهدف من هذه الدراسة هو التقييم البيئي لجودة مياه النيل الأبيض والتعرف علي مصادر تلوثة في ولاية الخرطوم (تم اخذ منطقة الدباسين كنموذج للدراسة) وذلك لان المنطقة توجد حولها العديد من المصانع ومحطات معالجة مياه الصرف الصحي والمؤسسات الخدمية وبعد التقصي والمتابعة لمعرفة مصادر التلوث للنيل في هذه المنطقة وجد ان هنالك مصرف في هذه المنطقة يصب مباشرة في النيل ويتكون المصرف من التقاء مصرفين هما مصرف محطة سوبا لمعالجة مياه الصرف الصحي ماراً بمجمع اليرموك العسكري والمصرف الاخر هو مصرف مياه الامطار في المنطقة بدأ الشك حول ما اذا كان السبب الرئيسي في التلوث هو هذا المصرف ام لا بالرغم من ملاحظة ان بعض الخصائص الفيزيائية مثل اللون والرائحة لهذه المياه تبين انه وبلا شك هو السبب ولكن لتحقيق هذا الهدف والتأكد تم اخذ عينات من المياه من نقاط مختلفة فاخذت العينة الاولي من محطة سوبا لمعالجة مياه الصرف الصحي قبل المعالجة والعينة الثانية بعد المعالجة كما تم اخذ العينة الثالثة من المصرف مباشرة بعد ان مرت المياه المعالجة من محطة سوبا بمجمع اليرموك العسكري كما اخذت العينة الرابعة من النيل علي بعد 13متر بعد دخول مياه المصرف في النيل وتم قياس و تحليل الخصائص الفيزيائية وهي (درجة الحرارة ،الرقم الهيدوجيني والتوصيلية النوعية) لجميع هذه النقاط ووجد ان كل هذه الخصائص ضمن الحد المقبول والمسموح به حسب ماحددته الهيئة السودانية للمواصفات والمقاييس للمخلفات السائلة بعد المعالجة وكذلك المواصفات المحددة بواسطة منظمة الصحة العالمية .كذلك اجريت اختبارات كيميائية لنفس العينات وهي (الأملاح الكلية الذائبة ، الأملاح الكلية العالقة ، الطلب البيولوجي على الأوكسجين ، الطلب الكيميائي على الأوكسجين والمعادن الثقيلة) وبينت النتائج ان كل العينات تجاوزت النسب فيها النسب التي حددتها الهيئة السودانية للمواصفات والمقاييس للمخلفات السائلة بعد المعالجة وكذلك المواصفات المحددة بواسطة منظمة الصحة العالمية مما يعني :

- تلوث مياه النيل الأبيض بمياه الصرف الصحي وهذا ظهر بصورة واضحة في نتائج تحليل طلب الاوكسجين الحيوي وطلب الاوكسجين الكيميائي للعينة التي اخذت من النيل فكانت النتائج (315 mg/l - 512) علي التوالي بينما الحد المسموح به هو (75-15mg/l) علي التوالي .
- تلوث مياه النيل الأبيض بمياه الصرف الصناعي وهذا يفسره زيادة معدني الكادميوم والرصاص في مياه

النيل حيث وجدت لنفس العينة (0.21-0.0052 mg/l) علي التوالي بينما الحد المسموح به (0.1- 0.003mg/l)علي التوالي اذن المصادر الرئيسية لتلوث مياه النيل هي:

- محطة الصرف الصحي سوبا وهذا يفسره نتائج التحليل للعينات قبل المعالجة و بعدها حيث لوحظ ان نسبة الاوكسجين الحيوي هي (270-290 mg/l) للعينات قبل وبعد المعالجة علي التوالي والاوكسجين الكيميائي هي (554 - 560 mg/l) علي التوالي اي ان نسبة المعالجة ضعيفة .

- مجمع اليرموك العسكري وهذا يفسره زيادة نسب المعادن الثقيلة في المصرف بعد ان مرت بمجمع اليرموك العسكري حيث وجدت نسبة الرصاص والكادميوم للعينات التي اخذت من المصرف (0.26 mg/l -0.007) علي التوالي وللعينات بعد المعالجة في محطة سوبا (0.004-0.02 mg/l) علي التوالي .

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Chapter One

Introduction and Literature Review

Chapter One

1. Introduction

1.1 Introduction

Water is essential for life on earth. Because of the importance of water, the pattern of human settlement throughout history has often been determined by its availability. The fertile river valleys abundant water represents the beginning of civilizations. With growth, demand for water has increased dramatically, and its uses have become much more varied as used in agriculture, industry, recreation, and non-ingested personal consumption. Frequently, each of these uses required a different level of quality in order for the water to be considered adequate. Water are exposed to innumerous natural and/or anthropogenic influence in the form of for example, sulfides; sodium chloride; metals e.g iron and toxic metals e.g. lead, cadmium and chromium; carbon components; pathogens, such as bacteria and viruses (Ali, 1999). These could be harmful to the human when high concentrations are found. The sources of water pollution is determined where human activities continue to influence the environment, which include farming, harvesting trees, constructing building and roadways, mining and disposing the water supply may cause additional problems. There is also a growing concern of pollution caused by the leaching of industrial wastes into the aquifers. It is important to understand that pollution can be defined in many ways, and the specific definition used in specific case can be important. For example, if an industry spewing forth contaminates to water can convince the public and the regular agencies that by their definition they are not polluting. Pressure to force them to clean up might never materialize; even (Aarne, and Jeffery 1983) stated that "Citizen has an inherent right to the enjoyment of pure though the results of inadequate waste disposal are obvious (Aarne, and Jeffery 1983). and `uncontaminated air and water and soil; that this right should be regarded as belong to the whole community and that no one should be allowed to trespass upon it by carelessness or his avarice his ignorance”.

Water is uniquely vulnerable to pollution known as a “universal solvent,” water is able to dissolve more substances than any other liquid on earth. it’s the reason we have cool-aid and brilliant blue waterfalls. it’s also why water is so easily polluted. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution. (Aarne, and Jeffery 1983).

1.2. Types of water pollution

1. 2.1.Groundwater

Groundwater gets polluted when contaminants from pesticides and fertilizers to waste leached from landfills and septic systems make their way into an aquifer, rendering it unsafe for human use. Ridding groundwater of contaminants can be difficult to impossible, as well as costly. Once polluted, an aquifer may be unusable for decades, or even thousands of years. Groundwater can also spread contamination far from the original polluting source as it seeps into streams, lakes, and oceans. (Aarne, and Jeffery 1983)

1.2.2.Surface water

covering about 70 percent of the earth, surface water is what fills our oceans, lakes, rivers, , nearly half of our rivers and streams and more than one-third of our lakes are polluted and unfit for swimming, fishing, and drinking. nutrient pollution, which includes nitrates and phosphates, is the leading type of contamination in these freshwater sources. while plants and animals need these nutrients to grow, they have become a major pollutant due to farm waste and fertilizer runoff. municipal and industrial waste discharges contribute their fair share of toxins as well. there's also all the random junk that industry and individuals dump directly into waterways. (Aarne, and Jeffery 1983)

1.2.3 .Ocean water

Eighty percent of ocean pollution (also called marine pollution) originates on land whether along the coast or far inland. Contaminants such as chemicals, nutrients, and heavy metals are carried from farms, factories, and cities by streams and rivers into our bays and estuaries; from there they travel out to sea. Mean while, marine debris particularly plastic is blown in by the wind or washed in via storm drains and sewers. our seas are also sometimes spoiled by oil spills and leaks big and small and are consistently soaking up carbon pollution from the air. the ocean absorbs as much as a quarter of manmade carbon emissions.

1.2.4. Point source

When contamination originates from a single source, it's called point source pollution. Examples include wastewater (also called effluent) discharged legally or illegally by a manufacturer, oil refinery, or wastewater treatment facility, as well as contamination from leaking septic systems, chemical and oil spills, and illegal dumping. The Environmental Protection Agency (EPA), regulates point source pollution by establishing limits on what can be discharged by a facility directly into a body of water. While point source pollution originates from a specific place, it can affect miles of waterways and ocean. (Aarne, and Jeffery 1983).

1.2.5. Nonpoint source

Nonpoint source pollution is contamination derived from diffuse sources. these may include agricultural or storm water runoff or debris blown into waterways from land. Nonpoint source pollution is the leading cause of water pollution in u.s. waters, but it’s difficult to regulate, since there’s no single, identifiable culprit. (Aarne, and Jeffery 1983).

1.2.6. Transboundary

It goes without saying that water pollution can’t be contained by a line on a map. transboundary pollution is the result of contaminated water from one country spilling into the waters of another. contamination can result from a disaster like an oil spill or the slow, downriver creep of industrial, agricultural, or municipal discharge. (Aarne, and Jeffery 1983)

1.3. Causes of water pollution

1.3.1. Industrial waste

industries produce a tremendous amount of waste ,which contains toxic chemical and pollutants causing air pollution and damage to our environment and us .they contain harmful chemical including ,lead ,mercury ,sulfur ,nitrates asbestos, and many others many industries ,not having proper waste management system ,drain the waste in the freshwater ,which goes into canals ,rivers and later into the sea . the toxic chemicals may change the color of water, increase the number of mineral called eutrophication, change the temperature of the water, and pose severe hazard to water organism. (dojlido, and gerald, 1993) .

1.3.2. Sewage and waste water

Used water is wastewater. it comes from our sinks, showers, and toilets (think sewage) and from commercial, industrial, and agricultural activities (think metals, solvents, and toxic sludge). the term also includes storm water runoff, which occurs when rainfall carries road salts, oil, grease, chemicals, and debris from impermeable surfaces into our waterways. more than 80 percent of the world's wastewater flows back into the environment without being treated or reused, according to the united nations; in some least-developed countries, the figure tops 95 percent. in the united states, wastewater treatment facilities process about 34 billion gallons of wastewater per day. these facilities reduce the amount of pollutants such as pathogens, phosphorus, and nitrogen in sewage, as well as heavy metals and toxic chemicals in industrial waste, before discharging the treated waters back into waterways. that's when all goes well. but according to estimates, our nation's aging and easily overwhelmed sewage treatment systems also release more than 850 billion gallons of untreated wastewater each year. the sewage water carries pathogens and, atypical water pollutant, other harmful bacteria's, and chemical that can cause serious health problems and thereby diseases. Micro organisms in water are known to cause some of the very deadly disease and become. the breeding ground for creatures that act as carrier's .these carriers inflict these diseases onto an individual via forms of contact .atypical example would malaria. (dojlido, and gerald, 1993).

1.3.3. Mining activates

mining is the process of crushing the rock and extracting coal, gold and other minerals from the underground .these element when extracted in the raw form, contain harmful chemical and can increase the number of toxic elements when mixed up with water which may result in health problems .mining activities emit a large amount of metal waste and sulfides from the rocks which is harmful to the water. (dojlido, and gerald, 1993) .

1.3.4. Marine dumping

The garbage produces by households in the form of paper, plastic, food, aluminum, rubber, glass, is collected and dumped into the sea in some countries .these items take 2weeks to 200 years to decompose. when such things enter the sea or river, they not cause water pollution but also harm animal in the sea or river. (dojlido, and gerald, 1993) .

1.3.5. Accidental oil leakage

Oil spill poses a huge threat to marine life when a large amount of oil spills into the sea and does not dissolve in water. it causes problems for local marine wildlife, including fish, birds and sea otters .a ship carrying a large quantity of oil if met with an accident such an oil spill can cause varying damage to species in the ocean, depending on the amount of oil spill, the toxicity of pollutant, and size of the ocean. (dojlido, and gerald, 1993).

1.3.6. The burning of fossil fuels

fossil fuels like coal and oil, when burnt produce a substantial amount of ash in the atmospheres. the particle which contain toxic chemical when mixed with water vapor result in acid rain .also carbon dioxide is released from the burning of fossil fuels results in global warming. (dojlido, and gerald, 1993).

1.3.7. Chemical fertilizers and pesticides

chemical fertilizers and pesticides are used by farmers to protect crops from insect and bacteria’s .they are useful for the plant growth .however, when these chemical are mixed up with water, they produce harmful pollutant for plant and animals also when it rains, the chemical mix up with rain water and flow down into rivers and canals which pose serious damage for aquatic animal. (dojlido, and gerald, 1993).

1.3.8. Leakage from sewer lines

a small leakage from the sewer lines can contaminate the underground water and make it unfit for the people to drink .also, when not repaired on time, the leakage water can come on the surface and become a breeding ground for insect and mosquitoes. (dojlido, and gerald, 1993).

1.3.9. Global warming

an increasing in the earth temperature results in the global warming due to the greenhouse effect .it increases the water temperature and results in the health of aquatic animals and marine species, which later results in water pollution. (dojlido, and gerald, 1993).

1.3.10. Radioactive waste

Radioactive waste is any pollution that emits radiation beyond what is naturally released by the environment. it’s generated by uranium mining, nuclear power plants; the element that is used in the production of nuclear energy is uranium which is a highly toxic chemical. and the production and testing of military weapons, as well as by universities and hospitals that use radioactive materials for research and medicine. Radioactive waste can persist in the environment for thousands of years, making disposal a major challenge. Accidentally released or improperly disposed of contaminants threaten groundwater, surface water, and marine resources. few major accidents have already taken place in Russia and Japan. (dojlido, and gerald, 1993).

1.3.11. Urban development

as the population has grown exponentially ,so has the demand for housing ,food and cloth .as more cities and town are developed ,they have resulted in increasing use of fertilizers to produce more food ,soil erosion due to deforestation ,rise in construction activities inadequate sewer collection and treatment ,landfills as more garbage is produced increase in chemical from industries to produce more materials. (dojlido, and gerald, 1993)

1.3.12. Leakage from the landfills

Landfills are nothing but a massive pile of garbage that produces the awful smell and can be seen across the city. When it rains, the landfills may leak, and leaking landfills can pollute the underground water with a large amount of contaminations (dojlido, and gerald, 1993).

1.3.13. Animal waste

The waste produced by animal washed away into the rivers when it rains it then gets mixed up with other harmful chemicals and causes various water borne diseases like cholera, diarrhea, dysentery, jaundice and typhoid (dojlido, and gerald, 1993).

1.3.14. Underground storage leakage

Transportation of coal and petroleum product through underground pipes is well known .accidental leakage may happen anytime and may cause damage to the environment and result in soil erosion. (dojlido, and gerald, 1993) .

1.3.15. Eutrophication

the increased level of nutrients in water bodies is known as eutrophication. it results in the bloom of algae in the water. it also depletes the amount of oxygen in the water that negatively affects fish and other aquatic animal population. (dojlido, and gerald, 1993).

1.3.16. Acid rain

Acid rain is essentially water pollution caused by air pollution .when the acidic particles released in the atmosphere by air pollution mix with water vapor, it result in the acid rain. (dojlido, and gerald, 1993).

1.4. The effects of water pollution

1.4.1. On human health

Water pollution kills in fact, it caused 1.8 million deaths in 2015, according to a study published in the lancet. Contaminated water can also make you ill. every year, unsafe water sickens about 1 billion people. and low-income communities are disproportionately at risk because their homes are often closest to the most polluting industries. Water borne pathogens, in the form of disease-causing bacteria and viruses from human and animal waste, are a major cause of illness from contaminated drinking water. diseases spread by unsafe water include cholera, giardia, and typhoid. even in wealthy nations, accidental or illegal releases from sewage treatment facilities, as well as runoff from farms and urban areas, contribute harmful pathogens to waterways. where cost-cutting measures and aging water infrastructure created the recent lead contamination crisis offers a stark look at how dangerous chemical and other industrial pollutants in our water can be. the problem goes far beyond flint and involves much more than lead, as a wide range of chemical pollutants from heavy metals such as arsenic and mercury to pesticides and nitrate fertilizers are getting into our water supplies. once they're ingested, these toxins can cause a host of health issues, from cancer to hormone disruption to altered brain function. children and pregnant women are particularly at risk. (dojlido, and gerald, 1993).

1.4.2 On the environment

in order to thrive, healthy ecosystems rely on a complex web of animals, plants, bacteria, and fungi all of which interact, directly or indirectly, with each other. harm to any of these organisms can create a chain effect, imperiling entire aquatic environments. when water pollution causes an algal bloom in a lake or marine environment, the proliferation of newly introduced nutrients stimulates plant and algae growth, which in turn reduces oxygen levels in the water. this dearth of oxygen, known as eutrophication, suffocates plants and animals and can create "dead zones," where waters are essentially devoid of life. in certain cases, these harmful algal blooms can also produce neurotoxins that affect wildlife, from whales to sea turtles. chemicals and heavy metals from industrial and municipal wastewater contaminate waterways as well. these contaminants are toxic to aquatic life most often reducing an organism's life span and ability to reproduce and make their way up the food chain as predator eats prey. that's how tuna and other big fish accumulate high quantities of toxins, such as mercury. marine ecosystems are also threatened by marine debris, which can strangle, suffocate, and starve animals. much of this solid debris, such as plastic bags and soda cans, gets swept into sewers and storm drains and eventually out to sea, turning our oceans into trash soup and sometimes consolidating to form floating garbage patches. discarded fishing gear and other types of debris are responsible for harming more than 200 different species of marine life. meanwhile, ocean acidification is making it tougher for shellfish and coral to survive. though they absorb about a quarter of the carbon pollution created each year by burning fossil fuels, oceans are becoming more acidic. this process makes it harder for shellfish and other species to build shells and may impact the nervous systems of sharks, clownfish, and other marine life. (dojlido, and gerald, 1993).

1.5.Water quality standards

Although pure water is rarely found in nature (because of the strong tendency of water to dissolve other substances), the characterization of water quality (i.e., clean or polluted) is a function of the intended use of the water. for example, water that is clean enough for swimming and fishing may not be clean enough for drinking and cooking. water quality standards (limits on the amount of impurities allowed in water intended for a particular use) provide a legal framework for the prevention of water pollution of all types. there are several types of water quality standards. Stream standards are those that classify streams, rivers, and lakes on the basis of their maximum beneficial use; they set allowable levels of specific substances or qualities (e.g., dissolved oxygen, turbidity, and ph) allowed in those bodies of water, based on their given classification. Effluent (water outflow) standards set specific limits on the levels of contaminants (e.g., biochemical oxygen demand, suspended solids, nitrogen) allowed in the final discharges from wastewater-treatment plants. Drinking-water standards include limits on the levels of specific contaminants allowed in potable water delivered to homes for domestic use. in the united states, the clean water act and its amendments regulate water quality and set minimum standards for waste discharges for each industry as well as regulations for specific problems such as toxic chemicals and oil spills. in the European union, water quality is governed by the water framework directive, the drinking water directive, and other laws (APHA,2005) .

1.6 Parameters of water quality

There are three types of water quality parameters physical, chemical, and biological (APHA,2005).

1.6.1 Physical parameters

Physical water parameters provide information about the habitat of resident organisms. Many plants and animals have preferences or requirements regarding water temperature, salinity, dissolved oxygen concentrations, turbidity (water clarity) and pH. In this study, the parameters pH, temperature and conductivity was included (APHA, 2005).

1.6.1.1Temperature

Temperature is an important parameter that regulates dissolution of gases such as carbon dioxide and oxygen. Rates and levels of chemical reactions are also affected by temperature. Therefore, it also affects biological activities (Drever, 1997).

1.6.1.2 pH

The parameter pH is a measure of the concentration of hydrogen ions in water.

Mathematically, it is represented as:

pH= -log [H+] The state of pH in natural waters primarily determines the fate of most geochemical processes like solubility, ion exchange, weathering, sorption, precipitation, and buffering capacity (Drever, 1997). A pH between 7.5 and 9 has been recommended for drinking water. However, normal lakes can naturally have a pH around 6. Acidified lakes can have a pH around 4. Unless the water is naturally acidic, a pH below 6 could harm life in the lake (Drever, 1997), since the biological life is dependent on a certain pH.

1.6.1.3 Conductivity

The electric conductivity, which is a measure of the ion strength in the sample, does also influence a lot of processes, such as the different state of metals and stability of colloids (Jonsson 2006). The total concentrations of dissolved metals and the electrical conductivity are in a close connection. The more salts (cations and anions) that are dissolved in the water, the higher are the value of the electric conductivity. The majority of metals, which remain in the water after a sand filter, are dissolved ions. Sodium chloride for example, is found in water as Na+ and Cl-. High purity water that in the ideal case contains only H2O without salts or minerals has a very low electrical conductivity. The water temperature affects the electric conductivity so that its value increases from 2 up to 3 % per 1 degree Celsius (Lenntech, 1998-2006).

1.6.1.4 Solids

Solids occur in water either in solution or in suspension. These two types of solids can be identified by using a glass fiber filter that the water sample passes Through (Tchobanoglous & Burton, 2003). By definition, the suspended solids are retained on the top of the filter and the dissolved solids pass through the filter with the water (APHA, 2005). If the filtered portion of the water sample is placed in a small dish and then evaporated, the solids as a residue. This material is usually called total dissolved solids or TDS (APHA, 2005). Total solid (TS) = Total dissolved solid (TDS) + Total suspended solid (TSS) .Water can be classified by the amount of TDS per liter as follows:

- Freshwater: <1500 mg/L TDS
- Brackish water: 1500–5000 mg/L TDS
- Saline water: >5000 mg/L TDS+

The residue of TSS and TDS after heating to dryness for a defined period of time and at a specific temperature is defined as fixed solids. Volatile solids are those solids lost on ignition (heating to 550°C) (APHA, 2005). These measures are helpful to the operators of the wastewater treatment plant because they roughly approximate the amount of organic matter existing in the total solids of wastewater, activated sludge, and industrial wastes (Spellman, 2013).

1.6.2 Chemical parameters

1.6.2.1 Dissolved oxygen

Dissolved oxygen (DO) is considered to be one of the most important parameters of water quality in streams, rivers, and lakes. It is a key test of water pollution (APHA, 2005).

the colorimetric method–quick and inexpensive, the Winkler titration the higher the concentration of dissolved oxygen, the better the water quality. Oxygen is slightly soluble in water and very sensitive to temperature. For example, the saturation concentration at 20°C is about 9 mg/L and at 0°C is 14.6 mg/L. The actual amount of dissolved oxygen varies depending on pressure, temperature, and salinity of the water. Dissolved oxygen has no direct effect on public health, but drinking water with very little or no oxygen tastes unpalatable to some people. There are three main methods used for measuring dissolved oxygen concentrations Method—traditional method, and the electrometric method (APHA, 2005).

1.6.2.2 Biological Oxygen Demand (BOD)

Bacteria and other microorganisms use organic substances for food. as they Metabolize organic material, they consume oxygen (APHA,2005). The organics are broken down into simpler compounds, such as CO2 and H2O, and the microbes use the energy released for growth and reproduction (Tchobanoglous & Burton, 2003). When this process occurs in water, the oxygen consumed is the DO in the water. If oxygen is not continuously replaced by natural or artificial means in the water, the DO concentration will reduce as the microbes decompose the organic materials this need for oxygen is called the biochemical oxygen demand (BOD). The more organic material there is in the water, the higher the BOD used by the microbes will be. BOD is used as a measure of the power of sewage; strong sewage has a high BOD and weak sewage has low BOD .The complete decomposition of organic material by microorganisms takes time, usually 20 d or more under ordinary circumstances (Tchobanoglous & Burton, 2003). The quantity of oxygen used in a specified volume of water to fully decompose or stabilize all Biodegradable organic substances are called the ultimate BOD or BODL. BOD is a function of time. At time = 0, no oxygen will have been consumed and the BOD = 0. As each day goes by, oxygen is used by the microbes and the BOD increases. Ultimately, the BODL is reached and the organic materials are completely.

1.6.2.3 Chemical oxygen demand (COD)

The chemical oxygen demand (COD) is a parameter that measures all organics:

the biodegradable and the non-biodegradable substances. It is a chemical test Using strong oxidizing chemicals (potassium dichromate), sulfuric acid, and heat, and the result can be available in just 2 h (APHA,2005), COD values are always higher than BOD values for the same sample (Tchobanoglous & Burton,2003).

1.6.2.4 Heavy metals

Natural water contains different concentrations of metals. Some of the different states are soluble in water while others exist in the solid phase. The total concentration of metals in any natural water is the summation of soluble metals and insoluble metals or metals bound to colloids (Drever, 1997). Toxic metals, including "heavy metals" are individual metals and metal compounds that negatively affect people's health. However, some metals are necessary in small amount to support life, although in larger amounts, they become toxic. Environmentally, heavy metals are of great concern. They are toxic to the all-living beings they are often discharged through the industrial and urban wastes into the water. Once present in water or soil, it is difficult to get rid of them (Connell, 1999).

1.6.2.4.1 Chromium (Cr)

Chromium is a transition element located in group VI the periodic table and the most toxic form, the hexavalent Cr(VI), is usually associated with oxygen to form the chromate (CrO42-) or dichromate $(Cr2O7)^{2-}$; (Randy et al. 2006). The abundance of chromium in the earth’s crust ranges from 100 to 300 mg/g. However, several industrial processes, including leather tanning and the production of refractory steel have converted it in a serious pollutant of air, soil and water (Randy et al. 2006). Cr (VI) is a priority pollutant and has been documented to be harmful to fauna; flora and human beings and chromium-containing water and wastewater are hazardous. Removal of Cr (VI) can be done by adsorption on a non-toxic natural substance (Sharma, Weng, 2006).

1.6.2.4.2 Lead (Pb)

Lead is a metal that has been used for a long period of time, for example in batteries, ammunition and alloying elements. The metal can cause toxic effects in humans and animals and is also an inhibitory substance for microbiological degradation processes. Also, it is one15 of the most common metals related to workplace illness. Lead is neurotoxin and even small amounts can be harmful, especially to infants, young children and pregnant women. Symptoms of long-term exposure to lower lead levels may be less noticeable but are still serious. Anemia is common and damage to the nervous system may cause impaired mental function (Bastawy and others. 2006). The metal enters the human body by food, water, and air. Lead can be introduced in drinking water through corrosion of water pipes when water becomes more acidic. Therefore, lead dissolved due to this acidity and into drinking water. Also, lead can enter drinking water when it sits for longer periods (longer than six hours) in household plumbing that contains lead (Bastawy et al. 2006).

1.6.2.4.3 Cadmium (Cd)

Cadmium is an extremely toxic metal commonly found in industrial workplaces, particularly where ore is being processed or smelted. Exposure to cadmium can cause a number of harmful health effects due to the ability to induce disturbances in +several organs and tissues following either acute or chronic exposure

(Marisela, 2006). Consumption of food or drinking water with high levels of cadmium can severely irritate or bother the stomach and cause vomiting and diarrhea. Breathing high doses of cadmium can damage the lungs and can cause death. We get cadmium in our body by breathing, eating, or drinking the substance or by skin contact (Bastawy et al. 2006)

1.7. The river Nile

the name of the Nile originates from the Gre,JHU V
+ek word "nelios", meaning river valley. the river Nile is the longest river in the world and it is a source of life to millions of people, flowing 6.825 km (4.238 miles) from south to north over 35 of latitude through civilization of great antiquity, and the Nile basin embraces nearly 3.2 km2 of the equatorial and north east Africa. the Nile water is derived from rainfall generating the two rivers, namely y the blue Nile and the white Nile coming from two major areas: the Ethiopian plateau and the mountainous hinterland of the great lakes in Uganda, respectively. the blue Nile, which is known as aabbay in Ethiopia, has its source at lake Tana (3.100 km2). the lake is located in north western Ethiopia lying nearly 1.800 meter above sea level and 1.500 kilometers upstream from Khartoum. the blue Nile drops about 410 meters and picks up the flow of two seasonal tributaries, the Dinder and Rahad rivers (collins1900-1988) . During flooding it also carries large quantities of silt from the highlands of Ethiopia (el-khodari, 2003). from its major source, lake Victoria, a body of fresh water of 69.485 km2 (27.000 square miles) in surface and one of the largest freshwater lakes of the world . Flows northwards through Uganda and into Sudan (collins1900-1988). the annual flow for the white Nile at varies between 20 and 22 billion cubic meters (el-khodari, 2003). the white Nile has a much lower gradient that the blue Nile and consequently its terraces rise far more gently ,at Khartoum, the blue Nile and the

white Nile merge into the single river. from downstream Khartoum, the river is called river Nile. also, 320 km north of Khartoum, they joined by the seasonal Atbara river that rises in the Ethiopian high land.

Figure (1. 1) River Nile

1.8. Importance of the River Nile

The river Nile is great importance for the population because Nile is the main source of drinking water for all those who live within these countries and it is a primary source of soil formation, which extends the hip and is transferred from the Ethiopian mountains during the flooding season, and benefited rights in agriculture. but factors like the rapidly growing population combined with the ecological consequence, and the increasing agricultural and industrial development, which demands more and more water, are problems facing the Nile water (Waterbury, 1979).

1.9. Pollution of the River Nile

For thousands of years, the people of Sudan have been depended on the Nile's water for survival since it is the main drinking water source in Sudan. one of the main environmental problems in Sudan is the problem with water pollution. this is particularly truth for Khartoum more than in any other city along the river, because Khartoum is the biggest city in Sudan and has the biggest population. the increasing number of citizens has certainly increased the sanitation problem (Ali, 1999); which, in turn, contributes directly to the quality of the Nile water as no treatment of the sanitation water is performed (el-khodari, 2003).

due to population growth in Khartoum and the parallel increasing anthropogenic activities, water pollution is increasing over time and facing an increasing problem (Ali, 1999). Polluted effluents discharged to the water system derive from several sources. one of effluents discharged to the water system derive from several sources. one of the major sources is the disposal of untreated or semi-treated domestic effluents into water bodies. excessive use of fertilizers and pesticides is another major source of water pollution despite the success in considerable reduction of the use of agro-chemicals during the past decade. additionally, many of the industrial establishments do not comply with the law, which means that they dump their wastewater untreated into surface water bodies as well as inject it into groundwater. there are many factories in the city of Khartoum that have impacts directly or indirectly on the river Nile, such as clay pits, i.e. industries for manufacture of building blocks, spread along the bank of the blue Nile for more than 50 kilo meters. the clay pits produce a lot of carbon dioxide generated from combustion of mud and outputs. another source of pollutants is the use of chlorine gas, i.e. Disinfection of water and bleaching processes the chlorine gas is soluble in water due to the formation of a mixture of hypo chlorous acid and hydrochloric acid, according to the equations:

$Cl_2 + H_2O = HOCl + HCl$

the hydrochloric acid is completely dissolved in water to chloride and a proton, of which the latter contribute to water's acidity. also, the chlorine compounds are effective chlorinators of natural organic matter present in the water and carcinogenic trihalo methane's and facilities has seen extensive discharge of untreated effluent into the river from domestic, agricultural and industrial sources in riparian states. organ chlorines may be formed (wef and asce, 1991). however, also the residual chlorine is toxic to many kinds of aquatic life. the chlorine compounds may cause chronic diarrhea, which is more deployed in areas close to the blue Nile in Khartoum (unmis, 2007), the river has been exposed to nonpoint source pollution such as chemicals and sedimentations from agricultural practices and very highly toxic substances from mining activities. in addition, there is severe point source pollution from domestic and industrial discharge especially in urban areas. the lack of adequate wastewater treatment.

1.10. Background about the area under study

the area is located on the borders of the white Nile, starting from the Azzouzab area (Egyptian irrigation) until Aldabasin bridge , there are two natural drains in the area, one of which is the rainwater drainage from the neighboring residential areas, and the second represents a main drain resulting from the joining of two drainage.

-the first drain (Egyptian irrigation): it descends from the eastern side heading west with a natural inclination to flow into the White Nile (al-azouzab). the second drain: it consists of a concourse the drain of rainwater coming from the areas of (al-azhari, al-aalamah, mayo) in addition to treated wastewater in the soba sewage station passing through the Elyarmouk factory of the military but after the deterioration of tree growth, illegal cutting and mismanagement of this forest, the treated water drainage line was diverted through a canal to the Elyarmouk forest, from where it follows the course of the creek to the white Nile. industrialization authority, and this drain passes through Jabra industrial zone (al-hawa street) and joined the other drain west of the complex Elyarmouk factory of the military .the plant receives 32 thousand cubic meters of wastewater per day. the treatment plant is fed by about 16 collection stations distributed in the city of Khartoum, namely: (Khartoum, ministry of foreign affairs, al-muqrin, al-quoz, Khartoum hospital, judicial, al-barkas, Neelain university, and Khartoum industrial zone) to treat and use it to irrigate trees in the tree belt forest. the two treatment lines pour the sewage and industrial wastewater network into one drainage channel outside the station and from there through a waterway to the Elyarmouk forest and from there to the rainwater drainage channel to the white Nile in the Aldabaseen area the direct discharge of untreated water into rivers increases the pollution of the water environment therefore, so we expect the white Nile to be polluted by sewage and industrial wastewater.

Figure (1 .2) Showing the discharge of sewage water inside Soba treatment plant (inlet)

Figure (1 .3) Showing the treatment of sewage water inside Soba treatment plant (outlet) by the stabilization bond

Figure (1.4) showing the discharge of treated water (sewage and industrial) outside Elyarmouk military complex on the channel carrying to the Nile

Figure (1.5.) showing the waste water (sewage and industrial) at the moment entered directly on the Nile.

1.11. Literature review

-The higher council for environment urban and rural promotion, (Khartoum state), for the purpose of periodic monitoring and follow-up of the Nile water make analysis 1n 2020 of water samples from (soba sewage station, drain before and after the Elyarmouk military complex, Aldabaseen area, and for the river Nile) the analysis included:

pH –Ec-T.D.S-BOD-COD-Cd-Ni-Cu and also make another analysis in 2019

For: pH –Ec-T.D.S-BOD-COD-Cd-SO4-2-CL.they found all the result obtained higher than the limit set by the Sudanese standard and specifications for waste water after treatment and to be discharged into rivers and used for various purposes that support my research objectives . (HCEURP Khartoum state report ,2019and 2020)

-Dr: Nadia Shakak in her PhD studies in 2014 made full analysis for the white Nile water in aldabaseen area and other areas along the river Nile analysis of parameter include: pH –Ec-T.D.S-BOD-COD-Cd-Ni-Cu-Pb –Zn – Fe. she found all the result recorded above the limit set by the Sudanese standard and specifications for waste water after treatment and to be discharged into rivers and used for various purposes that support my research objectives . (Nadia shakak PHD,2014)

-Student Omer Abd Alrahem Bastawy study the changes of water quality along the river Nile in his master's degree in 2007and made analysis for parameter included:

1. Temperature
2. Conductivity
3. pH
4. heavy metals lead (Pb), chromium (Cr) and cadmium (Cd)
5. Absorbable organic halogens (AOX)
6. Total organic carbon (TOC)
7. Nitrate, Phosphate, and sulphate

and he found all the result observed above the limit set by the Sudanese standard and specifications for waste water after treatment and to be discharged into rivers and used for various purposes that support my research objectives . (Omer,2007)

- another study made by the national and international team include : ministry of agriculture and forests government of Sudan , laboratory of efficient irrigation drainage and agricultural soil-water environment, college of water conservancy, and hydropower, Hohai university, Nanjing, 210098, china and Sudanese environmental conservation society in 2013 covering an area of about 39701 km2, in the white Nile state to study the effect of sugar industry into the river Nile in Sudan in order to improve water quality while promoting water conservation in the Nile basin a prior investigation carried out at Assalaya, one of the sugar cane processors in the region, had revealed that the factory's discharge into the river had BOD, COD, and TSS. and they found all the result observed above the limit set by the Sudanese standard and specifications for waste water after treatment and to be discharged into rivers and used for various purposes that support my research objectives . (Mohmmed Alnail and other ,2013).

1.12 Objectives

The aim of this study was to assess the water quality of the White Nile and identification of pollution at Khartoum state around aldabasin bridge relevant questions were:

are the main sources of pollution sewage water (soba sewage water treatment plant) or industrial water (Elyarmouk military complex and other industrial factories)?

are the concentrations of the investigated parameters found in white Nile within the acceptable concentrations for the drinking water?

do the concentrations found white Nile originate from the upstream water?

or

do they have other sources of pollution?

more precisely

how much does the white Niles contribute to the pollution of the Nile water, how much and who is responsible?

to answer these questions the following analyses were performed on water samples from different locations :

- Temperature
- Conductivity
- pH
- the heavy metals lead (Pb) and cadmium (Cd)
- BOD (biological oxygen demand) and COD (chemical oxygen demand)

the observed results are compared with the literature and Sudanese standard and then the findings are discussed.

Chapter Two

Material and Methods

Chapter Two

2. Material and Methods

2.1. Selection of sampling points

the criteria of selecting sampling points were based on the population density, areas of industrial or anthropogenic activities such as military manufacturing, food and detergent factories, waste water treatment facility and the river catchment areas (APHA, 2005) , as the research hypotheses we assume that the water before the treatment is highly polluted and after the treatment is clear.

2.2. Samples collection and storages

water sampling was carried out according to standard methods for examination of water and wastewater, (APHA, 2005) all samples were taken from the surface water in January 2021 in order to assess the water quality in the white Nile at the Khartoum city area, collection of samples and chemical analysis were required, samples from the white Nile were collected from different points within the Khartoum city at four collection point (at depth 30 cm) sample (1) inlet of soba waste water treatment facility sample (2) out let of soba waste water treatment facility sample (3) at the band after waste water treatment and bass Elyarmouk military sample (4) in the Nile at distance approximately 13 m after discharging water. the samples will contain not only elements that came with the original river before entering Khartoum but also amounts added from activities in Khartoum the sampling procedure was as follows: after settling of disturbed sediment, the bottles were labeled first such as sample one ,sample two , sample three and sample four then washed once with the sample. then, the bottles were filled with the sample and closed below the water surface to make sure that the bottles were filled totally without any air. the bottles containing the samples were then placed in their plastic bags and stored at normal room temperature ≈20 at that time until time of analysis. the water dedicated for the metal analysis were acidified immediately when they arrived to the laboratory by adding 1 ml nitric acid (1000 ml sample + 5 ml 50% nitric acid) to each bottle((boutron, 1990). by doing this, the samples were conserved and unwanted reactions were avoided (iso5667). then all the bottles were kept sealed and refrigerated at 4°c until the time of analysis (APHA, 2000).

2.3. Sampling strategy

Four water samples were collected from different points outside the river and inside the river:

(Figure 2.5). the samples were chosen as the following:

1. inlet of soba treatment plant
2. outlet of soba treatment plant
3. bond before enters the river
4. about 13 m after enters the river

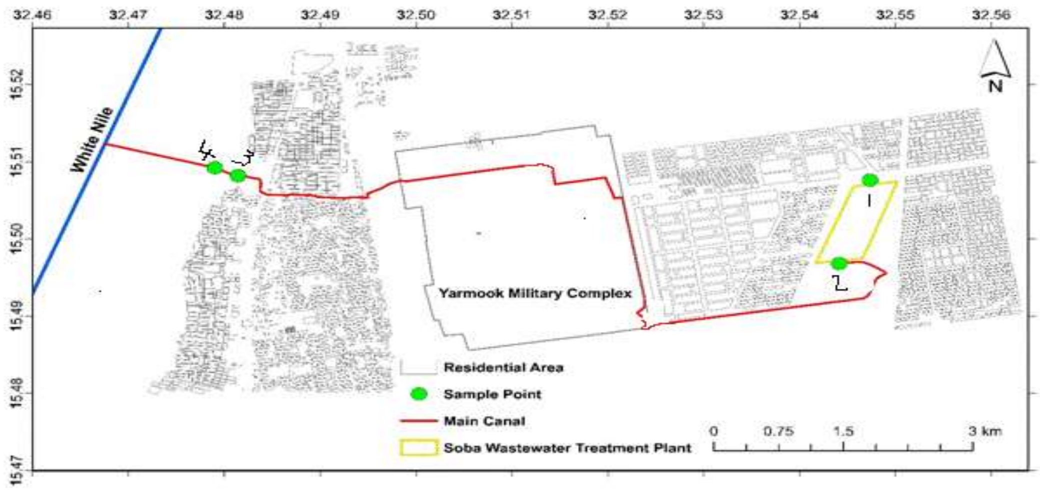

Figure (2 .1) showing different sampling points

2.4. Chemicals

Standard solution for Pb and Cd (0.1-0.2-0.3-0.3-0.4M) for each one

Potassium dichromate (0.01N)

COD reagent (H_2SO_4 +Ag_2So_4) (0.01M)

Ferroin indicator (0.1M)

Fe (NH4)2(SO4)2 .6H_2O (0.1M)

Dilution water includes:

Ferrous chloride (Fecl2) (0.1M)

Calcium chloride (Cacl2) (0.1M)

Magnesium Sulphate (MgSO4) (0.1M)

BOD Buffer (phosphate salts)

2.5. Apparatuses

Beakers

Burettes

Pipettes

Funnels

Test tubes

COD Rector

BOD bottle

Magnetic stirrer

Volumetric Flask

Pump

Incubator

PH meter WAP–CD 80

Conductivity meter

Atomic absorption (Pye Unicam Model)

2.6. Methods

2.6.1. pH

the pH value is determined by measuring the electromotive force of a cell consisting of an indicator electrode (an electrode responsive to hydrogen ions such as a glass electrode) immersed in the test solutions and a reference electrode (usually mercury/calomel electrode) using pH meter., four samples of water were analyzed by using WAP–CD 80 p H meter, as described by lind et al (1998).

2.6.2Total suspended solids (TSS)

Determination of total suspended solids of samples was carried out by application of the filtration method. the samples were firstly filtered using a vacuum suction and 45µmglass-fiber filters. the clean dried filters were oven dried at 105ºc for 4 hours until a constant weight was obtained to ensure that ambient moisture was not a source of systematic error. the filters were then placed in a desecrator. the dried clean filters were weighed on a scientific scale and measurements recorded to the nearest milligram described as by standard methods of examination (ASTM, 2000)

2.6.3. Total dissolved solids (TDS)

Determination of total dissolved solids of samples was carried out by application of the filtration method. the samples were firstly filtered using a vacuum suction and 45µmglass-fiber filters. the filtrate was then subjected to water bath treatment for evaporation till dryness. the container was then transferred to oven at 105ºC for 4 hours until a constant weight was obtained weight. the difference estimated as total solid. (ASTM, 2000).

2.6.4. Electrical Conductivity (EC)

Electrical conductivity is a function of total dissolved solids (TDS) known as ions concentration, which determines the quality of water (tariq et al., 2006). it is considered as a measure of the ability of ions in a solution to carry electric current. this ability depends on the presence of ions, their total concentration and temperature. for determination of electric conductivity in treated waste water, to specific volume of water, the probe of jenway 4510 conductivity meter was dipped. the electrical conductivity was read directly and recorded in μscm-1 (petersen ,1996).

2.6.5. Biological oxygen demand (BOD)

biological oxygen demand (BOD) examination is based mainly on bio-assay method which estimates the concentration of dissolved oxygen in mg per liter which consumed by the water micro-organisms while assimilating and oxidizing the organic matter under aerobic conditions. in this method, a BOD dilution water was prepared by air saturated distilled water by aeration for 1- 2 hrs, two ml of any of $FeCl_3$, $CaCl_2$, $MgSO_4$, and phosphate buffer were added. Sample temperature was brought to 20° C. A volume of the water and wastewater sample was transferred into 1000 ml volumetric flask and completed with BOD dilution water to the mark. the diluted sample was divided equally into three portions each of which was transferred into a BOD bottle. the dissolved oxygen of one bottle was measured immediately and the other two bottles were incubated at 20 C. after five days the dissolved oxygen was measured, the BOD was estimated by difference (Abida, 2008).

2.6.6. Chemical Oxygen Demand (COD)

Chemical oxygen demand is a measure of the equivalent concentration of oxygen that would be required to oxidize all of the organic matter plus some Oxidzable inorganic constituents in the sample (Kayaalp et al. 2010). for determination of chemical oxygen demand of treated water and waste water under study, 15 ml of the water sample were taken and diluted to twenty ml by distilled water and mixed well. to the diluted sample, ten ml of potassium dichromate solution (1N) and 30 ml of conc. sulphuric acid were added, the mixture was then subjected to high temperature under condensation apparatus for about 2 hours. the product was then titrated by ferrous ammonium sulphate solution(0.25N). the amount of COD was estimated as mg/L (APHA, 1995).

2.6.7.Heavy metals

for the determination of heavy metals, the sample of water was firstly subjected to digestion process, which was carried out according to standard analytical methods using nitric acid (HNO3). stock solutions were also prepared based on standard analytical methods adopted in walinga et al. (1989). for the analysis, the atomic absorption spectrophotometer (pye unicam model) was calibrated with standard solutions and the digested samples were directly analyzed for the presence and concentrations of Cd, and Pb at their respective detection wavelengths.

Chapter Three

Results and Discussion

Chapter three

3.1 Results and Discussion

Temperature, pH and Conductivity are very important parameters for water quality .Chemical reactions are influenced by temperature. Conductivity it is one of the main parameters used to determine the suitability of water for drinking , irrigation and firefighting.

Table (3. 1) represents the result of (Temperature, pH and Conductivity) obtained for the measured water samples.

Samples locations	**Temperature °C**	**pH**	**Conductivity µS/cm**
inlet of soba treatment plant	23*	6.70*	1.30*
out let of soba treatment plant	22.5*	6.95	1.60*
bond before entering the river	21*	6.72*	1.80*
about 13 m after entering the river	20*	7.24*	1.39*
Reference values	37c˚	6-9	50–1000

*** Average**

3.1.1 Discussion of Temperature, pH and conductivity

- Temperature was measured at the sampling area .The observed temperatures at the different sample locations were found to be within the range (20 and 23°c)

- PH of pure water is 7. In general, water with a PH lower than 7 is considered acidic, and above 7 alkaline. the normal range for PH in surface water systems is 6.5 to 8.5, (apec, 2007). The results of the PH measurements showed that all the samples were within the range considered normal for surface waters .

-Freshly distilled water has a conductivity of 0.5–2 µs/cm, and this value increases up to about 4µs/cm due to absorption of carbon dioxide and, to a lesser extent ,when absorbs ammonia from the atmosphere. for surface water, the conductivity is typically within the range 50–1000 µs/cm (dojlido, and gerald, 1993). some industrial waste water may have a conductivity value of several thousand µs/cm (dojlido, and gerald, 1993). The recommendation for drinking water quality stipulates maximum allowable value of 1500 µs/cm, while the recommended limit for river water is 1000 µs/cm (dojlido, and gerald, 1993), the result obtained which show that they are within the range of typical surface waters.

The (Total Dissolved salt(TDS) & Total Suspended salt (TSS)) may affect water or effluent quality adversely in a number of ways. Biochemical oxygen demand, chemical oxygen demand are parameters which indicate the presences of the organic pollutants .

Table (3.2) represent the result of (TDS, TSS, BOD and COD) obtained for measured water samples.

Samples locations	**TDS mg/l**	**TSS mg/l**	**BOD mg/l**	**COD mg/l**
inlet of soba treatment plant	518*	540*	290*	560*
out let of soba treatment plant	483*	360*	270*	540*
bond before	662*	180*	421*	670*

enteringthe river				
about 13 m after enters the river	647*	180 *	315*	512*
Reference values	15	75	1500	30

3.1.2 Discussion of Total dissolved solids (TDS), Total suspended solids (TSS), Biological oxygen demand (BOD5)and Chemical oxygen demand (COD)

- The TDS in the inlet of soba treatment plant was 518 ppm and in the out let is 483ppm this indicate there is no treatment and at the bond before enters the river (after passing Elyarmouk complex) was 662 ppm that means Elyarmouk complex contributed by 244ppm , at the river 647 the concentration is lower than the limit set by the Sudanese standard of specifications after waste water treatment to be discharged into rivers or used for other purposes .The allowable limits was 1500mg/l (Sudanese standard of specifications No174/2008 standard (A).

- The result of TSS in the inlet of soba treatment plant was 540 ppm and in the out let is 360 ppm . This indicates the treatment is not sufficient and at the bond before entering the river (after passing Elyarmouk complex) was 180 ppm and at the river 180 ppm that indicate the concentration of TSS inter the river the is higher than the limit set by the Sudanese standard of specifications for water after waste water treatment to be discharged into rivers or used for other purposes . The allowable limits was 30ppm (Sudanese standard of specifications No174/2008 standard (A).

- The results of biological oxygen demand in the inlet of soba treatment plant was 290 ppm while in the outlet is 270 ppm . This indicates the efficiency of treatment is not sufficient also at the bond after the treated water passing Elyarmouk complex was high 472 ppm that indicates there is no treatment of waste water coming from the Elyarmouk complex ,may be due to the discharged of some trucks loaded with waste water from the residential areas . The BOD value in the Nile recorded 315 ppm .This low value of BOD due to the diluted by the river . High BOD indicates low quality of treated waste water; however, it is no significant as used as water of irrigation. Although in most documents, no standard was adopted for BOD for irrigation water. however, salgot et al, (2006) reported the values of BOD of wastewater to be used as suitable water for perfect irrigation system should not exceed 20 mg/l, , BOD may range from 0- 100 ppm , for possible reuse of wastewater for irrigation, and from 100 – 200 ppm , for conditional reuse , however, values of BOD exceeding 200 ppm makes wastewater totally unsuitable for any irrigation systems known. The concentration in point four is higher than the limit set by the Sudanese standard of specifications after waste water treatment to be discharged into rivers or used for other purposes. The allowable limits was 15ppm (Sudanese standard of specifications No174/2008) standard(A).

- Table(3.2)shows the results of the chemical oxygen demand (COD) of the collection points , The COD in the inlet of soba treatment plant was 560 ppm while in the outlet 540 ppm this indicates the efficiency of treatment is not sufficient also the highest value 670 mg/L was recorded in the bond after passing Elyarmouk complex that indicates there is no treatment of waste water coming from the Elyarmouk factory and the discharged of some trunks loaded with waste water from residential areas in the bond .The COD value in the white Nile recorded 512 ppm the low value of COD is due to the effect of dilution of COD by the river water which is also found to be higher than the limit set by the

Sudanese standard of specifications after waste water treatment to be discharged into rivers and used for other purposes . The allowable limits was 75mg/l (Sudanese standard of specifications No 174/2008 standard (A)، Some researchers reported that if a concrete correlations between COD and BOD is done, it is very useful to replace the test of BOD 5 days with COD, because COD can be determine in 3 hours, compare with 5 days for the BOD5. It was reported the relationship between BOD and COD is highly significant to evaluate amenability of wastewater for biological treatment. If the ratio of BOD to COD is greater than or equal to 0.8, this reveals that waste water is highly polluted and amenable to the biological treatment (Clesceri et al., 2000) It is useful to evaluate strength of wastewater, which contain toxic materials and biologically resistant organic substances. Also COD can be related to total organic carbon (TOC), however, it does not account for oxidation of organic matter. It is well known that COD always higher than BOD value for domestic and some industrial waste water; COD value is about 2.5 times BOD value. For wastewater to be used as irrigation water or, the recommended value of COD was reported by Salgot et al, (2006) as 100 ppm , however, less value reflected lack of organic matter.

The results presented in **table (3.3)** represent the detected concentration of the heavy metals (cadmium and Lead) in four different sampling locations. Detailed observations of each metal are given below.

Samples locations	**Lead (Pb) mg/l**	**Cadmium (Cd) mg/l**
inlet soba treatment plant	0.021	0.0031
outlet of soba treatment plant	0.02	0.0032

bond before entering the river (after treatment and pass Eyarmouk military complex)	0.26	0.007
about 13 m after enters the river	0.21	0.0052
Reference Values (mg/l)	0.10	0.003

3.1.3 Discussion of Cadmium & Lead

- The concentration of cadmium at the inlet and outlet of soba treatment plant was recorded 0.0031 and 0.0032 ppm respectively this indicate the concentration of the metal remains same in the inlet and outlet of soba treatment plant that means waste water content lower value of heavy metal while the higher concentration of cadmium observed at the third point before waste water enters the river (after treatment and pass Elyarmouk military complex) 0.007ppm. The high level of concentration might be due to contribution of polluted waste water and insufficient of treatment for industrial waste water coming from Elyarmouk factory or maybe there is no treatment installed for this purpose . Also the discharged of some trucks loaded with industrial waste water from other industrial activities might contribute in rising the concentration . The decrease of the concentrations of cadmium at fourth collection point (about 13 m after entering the river) 0.0052 ppm may be to the dilution, removal of the metal or precipitation as cadmium carbonate(removal by the adsorption with the clay when it was flowing in the drain system) or precipitate due to higher concentration of carbon or adsorb into particulate matter and incorporate into the bottom sediment (dojlido, and gerald, 1993) generating a lower concentration of cadmium in the water phase or dilution factors .The concentration of cadmium in the river 0.0052 ppm is higher than the concentration limited by Sudanese standard and specifications after waste water treatment and to be discharged into the rivers to be used for various purposes . The allowable limits was (0.003mg/l) (Sudanese standard of specifications No174/2008 standard (A) .

- The concentration of lead in inlet and outlet of soba treatment plant was very low 0.020 and 0.021ppm respectively . Table (3.3) present the result of lead . The concentration of lead remains same in the inlet and outlet of soba treatment plant, That means the waste water contains lower value of heavy metal while the higher concentration of lead observed at the third point bond before waste water entering the river (after treatment and pass Elyarmouk military complex) is high . This high level of concentration might be due to polluted waste and insufficient of treatment for industrial waste water coming from Elyarmouk factory or maybe there is no treatment plant installed for this purpose also the discharge of some trunks loaded with industrial waste water from other industrial activities might contribute in rising the concentration . Although the decrease of concentrations of lead at fourth collection point (about 13 m after entering the river) may be due to the dilution factor of the waste by river water or removal of lead by precipitation as lead carbonate(removal by the adsorption with the clay when it was flowing in the drain system) or adsorb into particulate matter and incorporate into the bottom sediment . The concentration of lead in river water higher than the concentration limited by Sudanese standard of specifications after waste water treatment and to be discharged into rivers or to be used for other purposes . The allowable limits was 0.1ppm (Sudanese standard of specifications No174/2008 standard (A).

3.2. Summary and conclusion

The goal of this study was to assess the water quality of the white Nile at Khartoum state (adabasin as the study area) and identification of the pollution and sources of pollution ,Three important tasks were required to accomplish this goal: sampling (collecting four samples from different points) inlet soba treatment plant, outlet of soba treatment plant, bond before entering the river (after treatment and pass Eyarmouk military complex) and about 13 m after entering the river also analysis of different parameters (nine parameters were chosen to cover a broad range of possible influencing pollutants) pH, Temperature, Total suspended solids (TSS), Total dissolved solids (TDS), Electrical conductivity (EC), Biological oxygen demand (BOD), Chemical oxygen demand (COD), Heavy metals(cadmium and lead) . Then finally statistical analysis and evaluation of the results. **From this study there is different source of pollution :**

3.2.1 .Soba sewage station

Soba sewage plant contributes significantly to the pollution of White Nile water, where the results of the analysis indicate an increase in concentrations of pollutants that exceed the permissible limits.

3.2.2 .Elyarmouk military complex

The results of this study indicated that Elyarmouk complex has a clear contribution by increasing the concentration of heavy metals and industrial pollutants, which requires further investigation of the quality of industry within Elyarmouk complex.

3.2.3 Other industrial sources

By the observing of the discharge of industrial waste water on the canal transporting the treated sewage water , there is a trace of waste in the place of discharge indicated by the observation of the citizens in this area .

3.3. Recommendations

1/ activate laws and legislations on the protection of water resources

- the irrigation and sanitation low 1990
- environmental protection and natural resources low 2020
- the water resources low 1995

2/ improve the efficiency of the soba sewage treatment plant by developing the treatment to be a triple treatment (physical, chemical and biological).

3/ tighten controls to prevent factories from draining industrial wastewater on the canal (el hawa street).

4/ take strict measures to stop the discharge of partially treated wastewater directly into the Nile.

5/ the need to visit Elyarmouk military complex and review the nature of the coming water and the industrial drainage system inside the complex, because it has a highly contribution to increasing the concentration of pollutants at the point on the water exit from the complex.

6/ conduct an urgent environmental review of soba station and follow up its implementation by the higher council for the environment and related stake holder

7/ requiring industrial facilities to conduct internal treatment units conduct periodic tests (monthly at the highest discretion) and ensure that they comply with the surveyed limits before discharge into water sources.

8/ raising environmental awareness of the dangers of pollution at the risk of using contaminated water by involving the community in dealing with the sewage system

9/ speeding up the procedures for providing and allocating appropriate spaces and paths proposed by the sanitation authority to reuse water for forest irrigation purposes after making sure of the necessary treatment so that the treated water is not discharged directly to the Nile.

10/ review and approval of the proposed sanitation law to control the industrial sector by controlling the processing stages and reuse of industrial wastewater in various industries (boilers/cooling units/various consumption units) and adopting incentive policies for water recycling

11/ several samples from the same location i.e. for the same sampling point should have at least nine samples should be divided accordingly: triplicate samples from the approximately 1m from each waterfront, and triplicates from the middle of the river. by this sampling strategy, we make sure the water represents the whole area from where it was taken.

12/ by analyzing water from the house after passing the distribution lines, it might be possible to trace the source of the health problems. also, it is useful to know and quality of the water that enters the households after purification and filtration processes performed by the water treatment plant.

13/ analyze river sediment from different depths and trying to identify areas influenced by industrial activities.

14/ analyze of other heavy metals such as: Hg ,Cr,etc

15/ biological analyses, such as bacteria, because of its active role in human health.

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