

# Environmental Impacts of the liquid waste from Assalaya Sugar Factory in Rabek Locality, White Nile State, Sudan.

Khatir M. K. Ahmed<sup>1\*</sup>, Mona A. Haroun<sup>1</sup>, Jazem A. Mahyoub<sup>2,3</sup>, H.M. Al-Solami<sup>2</sup> and Hamed A. Ghramh<sup>4,5</sup>

<sup>1</sup>Dept. of Environmental health, Bahri Univ., Khartoum (Sudan).

<sup>2</sup>Department of Biology Sciences, Faculty of Sciences, King Abdulaziz University, Jeddah, KSA.

<sup>3</sup>IBB University, Ibb, Republic of Yemen.

<sup>4</sup>Department of Biology, Faculty of Science, King Khalid University, Abha 61413, P.O. Box 9004, KSA.

<sup>5</sup>Research Center for Advanced Materials Science, King Khalid University, Abha 61413, P.O. Box 9004, KSA.

**Abstract**— The study aimed to assess the environmental health impacts of the liquid waste from Assalaya Sugar Factory, the efficiency of the existing Assalaya effluent treatment plant, the dilution factors available in the White Nile to gather with wastewater environmental impacts. A descriptive cross-sectional focused on the Factory and its neighborhoods. Four hundred and thirty two out of 3931 households were statistically determined as the sample size, the individual samples were picked using multi-stage stratified method 432 households selected as sample size. Data were collected by using structured questionnaires, field observations, laboratory analysis and interviewing the concerned and affected persons. The effluent load discharged from the factory into the Al - jassir canal at the White Nile was analyzed for BOD, COD, pH, PO<sub>4</sub>, TDS, TSS, Turbidity, Color, and flow rate. The Data were processed by using the Statistical Package for Social Science (SPSS) version 16, Chi-square test, test associations and office excel 2007. The study showed that Eighty one percent of the households used the surplus irrigation canal as a source for water supply. 64% of the respondents suffered from diarrhea, vomiting and allergic diseases, the rather low rate of water consumption and the bad quality of water consumed were reflected adversely on hygiene and consequently increased water related diseases. The study concludes that always or sometime 49.5% of the water collectors were children and used animals and plastic containers for water collection and transportation. The conducted laboratory water analysis revealed that the average concentrations of PO<sub>4</sub>, COD and BOD of the raw wastewater produced by Assalaya Sugar Factory were 4260, 3800 and 1500 mg/l, respectively, these values were

above the WHO recommended concentrations for the disposed treated effluent (2, 250 and 30 mg/L respectively). As to physical analysis; the turbidity on the average was higher (540 NTU) and the color was (854 TCU) also high.

**Keywords**—Environmental Impacts, Liquid waste, Assalaya Sugar Factory, SPSS.

## I. INTRODUCTION

The environment is external to individual human host it can be divided into physical, biological, social and cultural, all of which can influence populations, health status [WHO, 1995]. The relationship of man with the environment is necessarily symbiotic; the equilibrium between the two must be maintained at all costs. Unfortunately, on account of the various activities of man, the composition and complex nature of environment get changed. Such activities include industrial, construction, transportation, etc. These activities, although desirable for human development and welfare, lead to generation and release of objectionable materials into the environment, thus turning it foul, and make our life miserable [UNDP 1994].

Urbanization and industrial growth complicate the problem because:

- 1- Natural resources were considered as free goods, but population growth puts a strain on these resources.
- 2- Environment is a sink where all the waste produced by man is assimilated.
- 3- These two facts reflect the importance of efficient utilization of resources and the minimization of both the quantity and toxicity of waste as important first stage interventions in environmental management, sound management of remaining waste will help to

protect the local and global environment [Tilak, K.S., Janardhana Rao, N.H. And Lakshmi, J. 1991].

#### **Industry and environment:**

Modern man and the complexity of his activities, especially in the fields of industry and technology produced substances that are foreign to the natural components. These substances affect the air or water or land or biological components. Macro and microorganisms have suffered from either some level of contamination that rose to dangerous pollution. Industrial processes produce liquid, solid and gaseous wastes which have negative effects on the environment and people; acid rain is an example, it results from emissions of sulfur dioxides and nitrogen oxides from chimneys and exhaust pipe. These wastes are generated either during processing, or at the end of the production process. At a closer range this atmospheric pollution can also increase respiratory diseases. Liquid wastes when disposed in water bodies without treatment greatly affect the aquatic organism [Roghaia, A.A. 1989].

#### **Waste and global issues:**

There are a number of aspects associated with waste, which have global implications. These include the effect on the ozone layer from CFCs, which remain in the old refrigeration equipment, and the greenhouse gases such as carbon dioxide and methane have been estimated to make a contribution seven to ten times greater than the same volume of carbon dioxide to the greenhouse effect. Rio conference objectives for waste management, as stated in the 1992 Earth summit Agenda:

- To minimize waste.
- To maximize environmentally sound waste re-use and recycling.
- To promote environmentally sound waste disposal techniques.

Local authorities should undertake recycling simply because of the local and global benefits, such as the recovery of CFCs, or the collection of waste automobile oil and diesel from garages which, if not managed properly, pollute water courses. The European Union has agreed a "proximity principle", which for waste requires that materials are handled and treated as close as possible to their point of origination, and not "exported to regions where waste management practices may be cheaper [Park, K., 1997]

#### **Regional effect:**

According to the fact that, all neighboring countries, share some geographical or geological structures (i.e. Rivers, lakes, aquifers, air and forests), then there is an interaction in all aspects. So certain problem can arise, such as

pollution (heat transfer and radiation), carbon dioxide buildup and greenhouse effect, and acid rain [Alexander P. Economopoulos, 1993]

#### **Local effects:**

The seed of pollution germinates within the local level, then expands to affect the neighboring countries to regional and global levels, some problems, such as smoking or malodorous industries, are local and can readily be controlled; the trouble is easily located and can usually be corrected by better methods of combustion or waste disposal. Industrialization and concentration of population in selected pockets of the country bring, in their wake, large quantities of industrial and sewage wastes which find their way into either the air or natural water bodies. Various gaseous emissions may be noxious and toxic or in the case of oxides being the source of acid rain. The wastes discharged directly to receiving water bodies where they impair water quality and affect aquatic life; threaten living organisms either in their health or their lives or their diversity [Idris, E., 1983].

#### **Pollution:**

##### **Definition:**

Pollution is defined as, the introduction by man of waste matter or surplus energy into the environment which directly or indirectly cause damage to man and his environment other than himself, his household, those in his employment and those with whom he has direct trading. While biologists define pollution as undesirable changes in the physical, chemical, or biological characteristics of air, water, land that can harmfully affect the health, survival activities of human or our living organisms. Therefore, pollution may either be man-made such as insecticides, pesticides or could be a substantial rise in matter which has already been in the environment such as ozone or destroying some natural component. Pollutants are introduced into the environment in significant amounts in the form of sewage wastes, accidental discharges or as by product of a manufacturing process or other human activity [Dix, H. M., 1981].

##### **Water pollution:**

Water pollution is defined by Dix (1981) as a natural change in the quality of water, which renders it unusable or dangerous with regards to food, human, animal health, industry, agriculture, and fishing or leisure pursuits. Also water pollution is defined by W.H.O in terms of:-

1- Its nature:

- Physical: temperature, suspended matter, color, ect.
- Microbiological: microorganisms such as bacteria, viruses, and protozoa.

- Chemical: mineral pollution (salts, heavy metals) or organic pollution (pesticide, hydrocarbons, solvent).

2- Its Origin:

**Urban:** Community wastewater, rain water, refuses tips.

**Industrial:** Liquid and solid waste from industrial activities (refineries, paper mills), storage of products (hydrocarbons, industrial wastes.) or extraction of raw materials (mines, quarries).

**Agricultural:** farming practices (fertilizers, plant protection products), slurry spreading the food industry (slaughter houses).

1- Its distribution in time:

**Permanent:** infiltration from leaching of waste discharges.

**Accidental:** broken pipes, overturned tanks.

**Seasonal:** plant protection products, highway deicing products.

2- Its distribution in space:

- Diffuse of agricultural origin, on-site sanitation.
- Localized: storage facilities, industries, and urban waste.
- Linear: highways, railways, rivers and watercourses.

#### **The ecological and economical damages:**

Damages caused by the untreated oil spill from industry and power generation unit to the sea, may result in mortality in birds and contamination of shore lines, resulting in severe biological effects on near shore organisms. Also may be fouling of vessels, nets and harbor facilities, requiring expensive clean up. The impact of oil on the open ocean environment is more difficult to assess, but it's likely that the spill will have some effects on fisheries and in general, on organisms present in the ocean surface waters. [Dix, H. M., 1981]

#### **Sources of water pollution:**

The major sources of water pollution can be classified as municipal, industrial, and agricultural. Municipal water pollution consists of wastewater from homes and commercial establishments for many years, the main goal of treating municipal. Wastewater was simply to reduce its content of suspended solids, oxygen-demanding materials, dissolved inorganic compounds, and harmful bacteria. In recent years, however, more stress has been placed on improving means of disposal of the solid residues from the municipal treatment processes. The basic methods of treating municipal wastewater fall into three stages: -

- Primary treatment, including grit removal, screening, grinding, and sedimentation.
- Secondary treatment, which entails oxidation of dissolved organic matter by means of using biologically active sludge, which is then filtered off.

- Tertiary treatment, in which advanced biological methods of nitrogen removal and chemical and physical methods, such as granular filtration and activated carbon absorption are employed.

The handling and disposal of solid residues can account for 25 to 50 percent of the capital and operational costs of a treatment plant. The characteristics of industrial waste waters can differ considerably both within and among industries. The impact of industrial discharges depends not only on their collective characteristics, such as biochemical oxygen demand and the amount of suspended solids, but also on their content of specific inorganic and organic substances. There are three options available in controlling industrial wastewater. Control can take place at the point of generation in the plant; Wastewater can be prorated for discharge to municipal treatment sources; or wastewater can be treated completely at the plant and either reused or discharged directly into receiving waters [World Bank. 1995]. Comprising over 70% of the Earth's surface, water is undoubtedly the most precious natural resource that exists on our planet. Without the seemingly invaluable compound comprised of hydrogen and oxygen, life on Earth would be non-existent, it is essential for everything on our planet to grow and prosper. Although we as humans recognize this fact, we disregard it by polluting our rivers, lakes, and oceans. Subsequently, we are slowly but surely harming our planet to the point where organisms are dying at a very alarming rate. In addition to innocent organisms dying off, our drinking water has become greatly affected as is our ability to use water for. In order to combat water pollution, we must understand the problems and become part of the solution [Mackenzie, 1996]. Water quality is closely linked to water use and to the state of economic development. In industrialized countries, bacterial contamination of surface water caused serious health problems in major cities. By the turn of the century, cities in Europe and North America began building sewer networks or domestic wastes downstream of water intakes [Mac Donnell, LJ 1996]. Development of these sewage networks and waste treatment facilities in urban areas has expanded tremendously in the past two decades. However, the rapid growth of the urban population (especially in Latin America and Asia) has outpaced the ability of governments to expand sewage and water infrastructure [Brassard, PG 1996].

#### **Industry in Sudan:**

Industry in the Sudan started with the turn of last century, when the expansion of cotton production was followed by the construction of ginning factories, industry for import

substitution started as recently as 1960. Sugar industry began at El Guneid in 1961, at El Girba in 1963 and at Asslaya in 1976. Then a tannery in Khartoum was established; followed by five dispersed food- processing plants. Before World War II, the British governor's policy in Sudan was to export agro industrial products. However, 1956, the year of political independence, could be taken as the gate for real industrialization in Sudan.

#### **Assalaya Sugar factory**

The main responsibility of the factory is to process cane into sugar at the highest possible yield and the lowest possible cost. The factory is designed to crush 6500 tons of cane daily to produce 110,000 tons of sugar. Due to raw materials, major technical, and manufacturing defects the factory did not reach the design capacity. The factory has no proper system for wastewater disposal. Twelve samples of river water and wastewater are to be collected and tested for the following parameters {Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Phosphate content (Po<sub>4</sub>), PH, Total dissolved solid (TDS), Total suspended solid (TSS), Turbidity, Color and Conductivity}.

#### **Cane Cultivation Area:**

The area planned for cane cultivation of is 33282 acres, but only 28648 acres are actually handled, out of which four thousand acres proved to have too much sodium salt, which resulted in low cane yields. It is planned to increase the area to match the design capacity of the factory by adding another 8500 acres considered as a first stage. The crop is cultivated by sprouts and harvested at the age of 10-16 months.

#### **Irrigation:**

Water is pumped every 10 days by a series of pumping stations comprised of 16 pumps, {five pumps (30 m<sup>3</sup>/second) located in the first station, four pumps (24 m<sup>3</sup>/second) in the second station, four pumps (22 m<sup>3</sup>/second) in the third station and three pumps (15 m<sup>3</sup>/second) in the fourth station}. The distance between a first station and second station is 6 km, second station to third station is 4 km, third station to fourth station is 8 Km. The actual requirement to operate the pumps was calculated to be nine megawatts and the daily water discharges to be 90000 m<sup>3</sup>.

#### **Quantity of waste products from the Factory:**

The quantity, of molasses is estimated to be:-  
3.5% of crushed cane weight, which is equivalent to 35000 tons per season of operation of 170 days. 3.25% of cane weight, which is equivalent to 32500 tons during the operation period. 4.5% of Bagasse weight from cane, which is estimated at 45000 tons during the operation

period. Water consumed for wash and boil which is estimated to 27000m<sup>3</sup>/h. [Ministry of industry & Ministry of finance 1995]. The traditional handcraft industries, such as wood products, leather and ivory; have been in existence since ancient times. Their success depends on small capital and the use of the local raw materials. The development of cotton ginning can be marked as a second stage of industry, in many ways. Thus the government policy has been to promote industrial and agricultural expansion. The first step was the approval of the Enterprises Act of 1956, which was issued to encourage the local and foreign capital investments in industry. This raised the current prices of products at the time from 1% in 1955/56 to 9.4% in 1970/71, and employment jumped from 900 to 4000 during the same period in 1960 [Boon, C. J., 1990]. The contribution of the industrial sector increased to 7.6%, and in 1973 increased to 15%. However, it fell to 8% in 1981 and went further down to 5% in 1985. Industry plays a relatively small role in the economy of the Sudan and accounts for less than twelve percent of GDP, ten percent of employment and less than one percent of exports. Manufacturing employment is about 2000,000 people. The sector suffers from infrastructure bottlenecks and shortages of trained manpower, raw materials and the foreign exchange needed for importing essential intermediate inputs [Elhaj, K. O. (1984)]. This situation agreed with the fact that says industrial development is given a high priority in most developing nations because such as development creates employment and generates revenue that is badly needed. Most of the industries in the Sudan are found in the urban areas except industries that are attracted to their source of raw material; Khartoum, Khartoum North, Omdurman, Port Sudan, Maringan & Gadida El Thawra industrial areas are examples of industrial complexes in urban areas, whereas sugar factories, textile, jute and cement factories are better examples of those attracted to their source of raw material throughout Sudan [Shakkak, N. B. 1985].

#### **Objectives:**

- Determine the pollution loads from the Factory, which are disposed in an Aljassir canal on the White Nile by using various parameters (e.g. BOD, COD, pH, PO<sub>4</sub>, TDS, TSS, Turbidity, color, conductivity and the effluent flow rate).
- Evaluate the existing industrial effluent treatment and disposal system installed by the Assalaya Sugar Factory and determine efficiency.
- Evaluate the effluent pollution problem caused by Assalaya Sugar Factory in the White Nile in general and in Aljassir canal particularly.

## II. MATERIALS AND METHODS

### Study Design and Setting

To achieve this work the following descriptive cross- entail, a study was conducted in order to evaluate the Environmental Health Impact of Assalaya Sugar Factory (ASF) in Rabek. Questioning about industrial liquid waste from the plant was studied, with special emphasis on liquid waste discharged from the Assalaya Sugar Factory.

### Sampling Methods:

$$n = \text{deff} * \frac{Z^2 * S^2}{d^2} \quad [\text{Murray Speigal} - 2004 - \text{Statistics} - \text{Schuam Senes}]$$

Where:-

Z = the standard normal variable corresponding to 95% confidence interval (Z = 1.96).

S = Standard deviation. (S = 3.1622777).

d = Margin of error. (d = 0.4219).

n = Represent the required size of the sample.

deff = (design effect = 2).

Sample size result:-

$$n = \text{deff} * \frac{Z^2 * S^2}{d^2} = 2 * \frac{(1.96)^2 * (3.162)^2}{(0.4219)^2} = 2 * \frac{(3.8416) * (10)}{(0.1779)} = 431.8 = 432 \text{ HH}$$

Accordingly a sample size of 432 HH was attained.

Where:

$$\text{The sub sample size (nh)} = \frac{N_h * n}{N}$$

h = Central Sector, Western Sector, Eastern sector.

N h<sub>1</sub> Total of household on one sector

n = (432) a sample size of HH.

N = (3931) total of household sectors

$$n_1 = \frac{N_1 * 432}{N}$$

The sub sample size result: -(n<sub>1</sub> = 122, n<sub>2</sub> = 220, n<sub>3</sub> = 90)

2) Sites of sample collection: to Laboratory analysis for Assalaya Sugar factory effluents (both chemical & physical analysis), across the treatment plant, Aljassir Channel and the White Nile.

The samples were collected from twelve sites randomly in the production season and Non production season

1) A Questionnaire to households in the residential area, according to sample size selection (. 432 out of 3931 HH.)

2) Laboratory analysis for Assalaya Sugar factory effluents (both chemical & physical analysis), across the treatment plant, Aljassir Channel and the White Nile.

### Sample Size:

1) The total numbers of households are 3931 where 432 households were selected as sample size from the study population by using the following sample formula

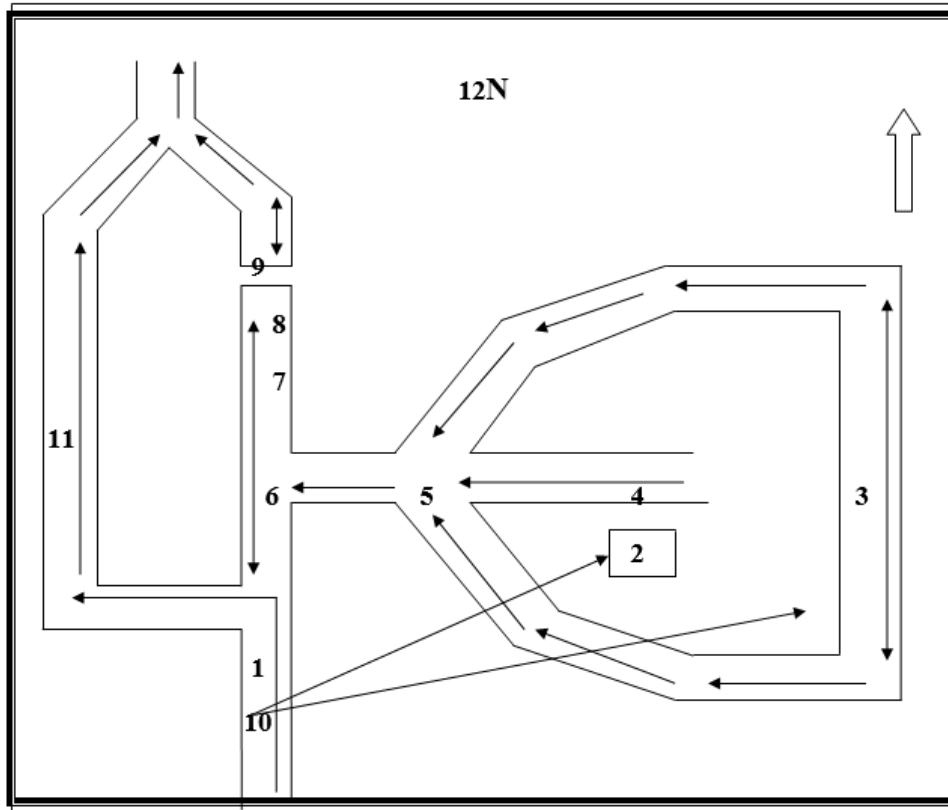


Fig: Locations of water and wastewater sampling in an Assalaya Sugar factory, Al-Jassir channel and White Nile

**Data Collection:** The data it was divided to tow section, section one was collected by using a structured questionnaire to households in the residential area according to sample size selection (. 432 out of 3931 HH.) and section tow by using Laboratory analysis for Assalaya Sugar factory effluents (both chemical & physical analysis),

across the treatment plant, Aljassir Channel and the White Nile.

**Data analysis:** Data were analyzed by using SPSS version 16, and the chi - square test was carried out with 95% confidence level to find associations between the different variables. P-values less than 0.05 were considered statistically significant.

### III. RESULTS AND DISCUSSION

Table.1: PO4 – (Phosphate) concentration

Po4 mg/L		Po4 mg/L (1)	Po4 mg/L (2)	Po4 mg/L (3)
Total	Mean	9.7917	8.6676	2.3167
	Std. Deviation	1.39828	2.96758	1.41860
	N	12	12	12
	Minimum	30.00	.15	30.00
	Maximum	4260.00	1.03	470.00
	Variance	1.955	8.807	2.012

Table.2: Concentration of (Chemical Oxygen Demand)

COD mg/L		COD mg/L (1)	COD mg/L (2)	COD mg/L (3)
	Mean	2.0031	1.8362	1.0385
	Std. Deviation	2.71724	3.17653	1.97526

<b>Total</b>	<b>N</b>	<b>12</b>	<b>12</b>	<b>12</b>
	<b>Minimum</b>	<b>8.00</b>	<b>1.12</b>	<b>6.67</b>
	<b>Maximum</b>	<b>3000.00</b>	<b>1000.00</b>	<b>3800.00</b>
	<b>Variance</b>	<b>7.383</b>	<b>1.009</b>	<b>3.902</b>

Table.3: Biochemical Oxygen Demand (BOD) Concentration

<b>BOD mg/L</b>		<b>BOD mg/L (1)</b>	<b>BOD mg/L (2)</b>	<b>BOD mg/L (3)</b>
<b>Total</b>	<b>Mean</b>	<b>3.9075</b>	<b>7.3890</b>	<b>7.3786</b>
	<b>Std. Deviation</b>	<b>8.87088</b>	<b>1.38637</b>	<b>1.37207</b>
	<b>N</b>	<b>12</b>	<b>12</b>	<b>12</b>
	<b>Minimum</b>	<b>3.00</b>	<b>4.30</b>	<b>4.30</b>
	<b>Maximum</b>	<b>600.00</b>	<b>250.00</b>	<b>1500.00</b>
	<b>Variance</b>	<b>7.869</b>	<b>1.922</b>	<b>1.883</b>

Table.4: Concentration of turbidity (NTU)

<b>Turbidity (NTU)</b>		<b>Turbidity (NTU) (1)</b>	<b>Turbidity (NTU) (2)</b>	<b>Turbidity (NTU) (3)</b>
<b>Total</b>	<b>Mean</b>	<b>129.5000</b>	<b>143.3333</b>	<b>51.7500</b>
	<b>Std. Deviation</b>	<b>1.60855</b>	<b>2.01239</b>	<b>93.05924</b>
	<b>N</b>	<b>12</b>	<b>12</b>	<b>12</b>
	<b>Minimum</b>	<b>16.00</b>	<b>10.00</b>	<b>2.00</b>
	<b>Maximum</b>	<b>470.00</b>	<b>540.00</b>	<b>336.00</b>
	<b>Variance</b>	<b>2.587</b>	<b>4.050</b>	<b>8660.023</b>

Table.5: Degree of color

<b>Color (Tcu)</b>		<b>Color (Tcu) (1)</b>	<b>Color (Tcu) (2)</b>	<b>Color (Tcu) (3)</b>
<b>Total</b>	<b>Mean</b>	<b>1.6642</b>	<b>2.1233</b>	<b>2.3417</b>
	<b>Std. Deviation</b>	<b>2.27330</b>	<b>2.25340</b>	<b>2.66283</b>
	<b>N</b>	<b>12</b>	<b>12</b>	<b>12</b>
	<b>Minimum</b>	<b>18.00</b>	<b>10.00</b>	<b>20.00</b>
	<b>Maximum</b>	<b>854.00</b>	<b>640.00</b>	<b>743.00</b>
	<b>Variance</b>	<b>5.168</b>	<b>5.078</b>	<b>7.091</b>

Table.6: Source of used water , 2013

<b>Source of used water</b>	<b>No</b>	<b>%</b>
<b>Main canals</b>	<b>80</b>	<b>18.5</b>
<b>Surplus irrigation water</b>	<b>350</b>	<b>81.0</b>
<b>Others</b>	<b>2</b>	<b>0.5</b>
<b>Total</b>	<b>432</b>	<b>100</b>

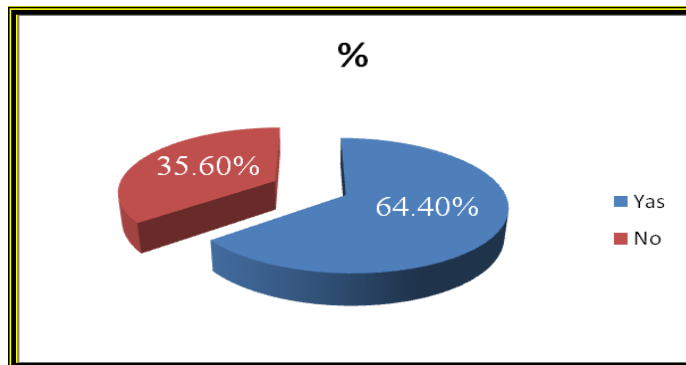


Fig.1: Percentages of the diseased

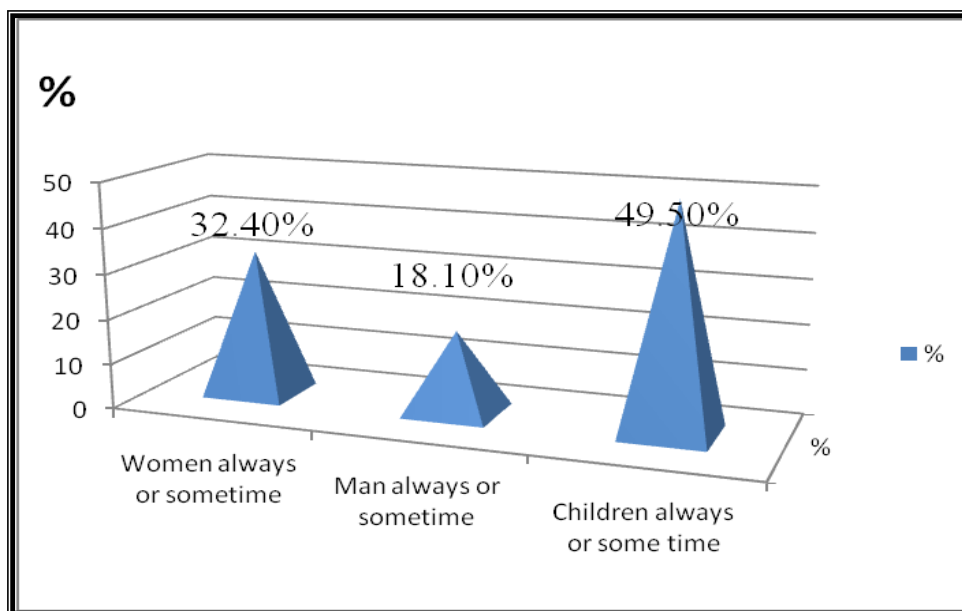


Fig.2: Water collectors

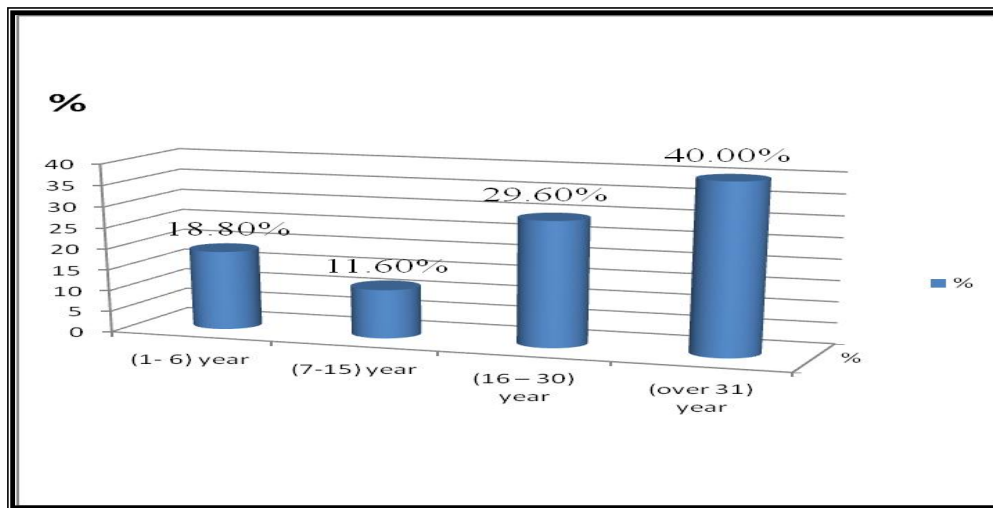


Fig.3: Age distribution of people affected



This study was conducted to evaluate the Environmental Health Impact of the liquid waste of Assalaya Sugar Factory in Rabek locality.

Regarding water and waste analysis the PO<sub>4</sub> concentration was 4260 mg/L which is higher than the recommended concentration by the WHO 2 mg/L, in (Industrial sewage and irrigation effluent) {Table 1}, comparison by the phosphorus (as orthophosphate) is the limiting nutrient in freshwater and aquatic system. The natural total phosphorus is generally less than 0.03 mg/l, whereas the natural levels of orthophosphate usually range from 0.005 to 0.05 mg/l. No guideline values suggested by WHO for drinking water, however the EPA water quality criteria state that phosphates should not exceed 0.05 mg/l if streams discharge into lakes or reservoirs, 0.25 mg/l within a lake or reservoir and 0.1 mg/l in streams or flowing waters [WHO, 2006]. Also the COD concentration was 3800 mg/L which is higher than the permissible level according to the WHO standard 150 mg/L {Table 2}. BOD concentration was 1500 mg/L which is higher than the WHO recommended concentration 30 mg/L {Table 3}. Comparison by the Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days. If effluent with high BOD levels is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river. The oxygen may diminish to levels that are lethal to most fish and many aquatic insects. As the river re-aerates due to atmospheric mixing and as algal photosynthesis adds oxygen to the water, the oxygen levels will slowly increase downstream. The drop and rise in DO levels downstream from a source of BOD are called the DO sag curve [Sudanese Standards and Metrology Organization SSMO2007]. The Self-purification aspects of rivers were given strong consideration when BOD standards were established for these water bodies. The waters having a BOD of less than 1 mg/l can be relatively unimpacted by humans and primary candidates for conservation. About 31.4%, 29.9% and 13.8% of drinking water sources in Japan, have BOD values less than 1 mg/l, 2 mg/l and 3 mg/l, respectively. If BOD exceeds 3 mg/l, it affects coagulation and rapid sand-filtration processes, conventional water treatment plants, requiring expensive advanced water treatment. Therefore, BOD standards are set

at 2 and 3 mg/l, respectively, for glass 2 and 3 waters. For class {I} fisheries, BOD is set at less than 1 mg/l, since oligosaprobic fishes such as salmon and smelt require water with a BOD Less than 2 mg/l. For class {II} fisheries, BOD is set at less than 2 mg/l, since mesoprobic fish such as carp require water with a BOD Less than 3 mg/l. For class {III} fisheries, BOD is set at less than 3 mg/l, since class {III} fisheries require water with a BOD Less than 5 mg/l. For class E, conservation of environment, BOD is set at less than 10mg/l to prevent odor caused by the anaerobic decomposition of organic matter [WHO, (2006)]. As to the physics analysis; the turbidity concentration was 540 NTU and color was 854 TCU, which are higher than the permissible levels for drinking water according to SSMO standards (5 NTU, 15 TCU) respectively. {Table 4,5}. Comparisons by the turbidities of 10 NTU or less represent very clear waters; 50 NTU is cloudy; and 100- 500 or greater is very cloudy to muddy. Some fish species may become stressed at prolonged exposures of 25 NTUs or greater. Furthermore, Barnes (1998) recommended that to maintain native fish populations in Georgia Piedmont Rivers and streams that random monthly values should never exceed 100 NTU; that no more than 5 percent of the samples should exceed 50 NTU; and no more than 20% should exceed 25 NTU. Similarly, average TSS concentrations in the range of 25-80 mg/L represent moderate water quality. An average concentration of 25 mg/L has been suggested as an indicator of unimpaired stream water quality. High turbidity levels affect fish feeding and growth; the ability of almonds to find and capture food is impaired at turbidities from 25 to 70 NTU. Gill function in some fish may also be impaired after 5 to 10 days of exposure to a turbidity level of 25 NTU. Turbidities of less than 10 describe very clear waters. Turbidity units are supposed to correspond to TSS concentrations, but this correlation is only approximate. Turbidity in a stream will fluctuate before; during and after storm flow give general criteria for all waters, which include narrative standards for turbidity: "All waters shall be free from material related to municipal, industrial or other discharges which produce turbidity, color, odor or other objectionable conditions which interfere with legitimate water uses," [Sudanese Standards and Metrology Organization SSMO 2007]. The study explained also the community responses and the surveyed study area revealed that there wasn't disposal system of (Industrial sewage and irrigation sewage) in an Assalaya Sugar factory and disposed directly on the Al – jassir channel. Comparison by

the All sugar factories were found to be releasing factory wastewater directly into the Blue and White Nile without pre-treatment. This wastewater contains an elevated biological oxygen demand (BOD), which can reach 800-3,000 ppm. The resulting pollution of river water is suspected to be the leading cause of frequent fish kills, particularly in the Blue and White Nile. It should be noted that the Kenana factory is in the process of constructing a wastewater treatment plant to address this problem. Others have yet to follow suit [UNEP teams. 2010]. Regarding knowledge about the problems related to the (81%) of householders used the source of water from surplus irrigation {Table 6} the study also revealed that the effluent pollution from Asslaya Sugar Factory within the survey showed that the (64.4%) of householders were the affected by diarrhea or vomiting or allergic disease as the result using of main canals for drinking, {Figure 1} , and water collectors there were children, the outcome of the study shows that effect of used surplus irrigation water for drinking in (49.5%) of householders, {Figure 2} The study indicated that 40% of the affected among the population were over 31 year of age, {Figure 3} comparison by the all the pathogens discussed in the previous section have the potential to reach the field. From the time of excretion, the potential for all pathogens to cause infection to usually decline due to their death or loss of infectivity. The ability of an excreted organism to survive outside the human body is referred to as its persistence. For all the organisms, survival is highly dependent on temperature with greatly increased persistence at lower temperatures. Also the first exposure of excreted pathogenic organisms outside the body is usually water. This blend with fresh water is often referred to as sewage. This sewage is then subjected to treatment prior to discharge, used directly for crop production or discharged to a watercourse where indirect use then occurs downstream. There are many studies on the survival or persistence of excreted organisms in water and sewage [FAO – Swedish Defence research agency 2004]. The surface water streams are also affected by industrial effluents and organics. Most of the treated industrial effluents are disinfected with chlorine which reach the receiving bodies and react with organic compounds to form chlorinated organics. The presence of these compounds in the water can cause cancer. Nitrates and nitrites are common inorganic pollutants that are released from fertilizer industries and excess nitrite levels are fatal to infants (blue disease) and also lead to eutrophication of water bodies. The major pollutant from the cement and thermal power industries is particulate matter that causes

diseases. Some people are likely to experience pneumoconiosis (respiratory allergies, asthma and lung diseases) [Mohamed, A.A., 1999]. The differences in pressure can cause contaminants to be drawn or forced into the distribution system. Contamination introduced due to backflow into the distribution system then flow freely into other customer connections. The following conditions must be present for contamination to occur through cross-connections:

- A cross-connection exists between the potable water distribution system and a non-potable source.
- The pressure in the distribution system either becomes negative or the pressure of a contaminated source exceeds the pressure inside the system.
- The cross-connection is not protected, or the connection is protected and the mechanism failed, allowing the backflow incident. The extent of contamination in the distribution system depends, in part, on the location of the cross-connection, the concentration of the contaminant entering the distribution system and the magnitude and duration of the pressure difference causing the backflow [Survey of State and Public Water System Cross-Connection Control Programs. Washington. U, S.A 2000]. The health hazards associated with direct and indirect wastewater use are of two kinds: the rural health and safety problem for those working on the land or living on or near the land where the water is being used, and the risk that contaminated products from the wastewater use area may subsequently infect humans or animals through consumption or handling of the foodstuff or through secondary human contamination by consuming foodstuffs from animals that used the area [FAO, 2004].

#### **Wastewater Treatment Plants:**

Assalaya Sugar factory is located North Rabak town (300 Km South of Khartoum), White Nile State, Sudan. Rabak is bordered on the west by the White Nile River. The Assalaya Sugar factory started production in 1979 – 1978 with a design capacity of 6,500 Tonne of the cane / Day and with an annual production of 110,000 tons/year of refined sugar.

The installed wastewater treatment system for the factory is a biological treatment system. It consists mainly of three stages:

**Anaerobic Pond.** The effluent of the mill house and process are passed through screens and grease traps, and then drained by gravity into an anaerobic pond. The anaerobic pond is deep, allowing the anaerobic degradation of the organic matters to take place through microbiological growth.

Facultative pond: The effluent of the anaerobic pond is drained by gravity into the facultative pond. Facultative has longer retention time, less depth and large surface area necessary for algal growth and consequent aerobic action.

Maturation Pond: The effluent of the facultative pond is then drained into a shallow Maturation Pond to allow for

further polishing and aerobic action [Elhassan, B.M and Rabih A, 2012].

The effluent from the Maturation Pond is discharged (via a lift station) into the cane field irrigation system.

Table: Assalaya WWTP design features.

Pond	Depth m		Area m <sup>2</sup>	Volume m <sup>3</sup>	
	Total	Water		Total	Water
Anaerobic	5.84	4.0	9672	56484	38668
Facultative	3.65	1.5	33825	123462	50737
Maturation	3.89	0.8	33345	129712	26676

#### White Nile flow next to the factory ( Malakal & Khartoum) \* 10<sup>6</sup>M<sup>3</sup>/d

Month	Nov.	Dec.	Jan.	Feb.	M.	AP.	May
Malakal	78	73	58	65	78	61	411
Khartoum	99	79	54	45	41	42	46
Average	88.5	76	56	55	59.5	51.5	43.5
Assalaya W.W	5976M <sup>3</sup> /d						
Dilution factor	14809	12718	4371	9203	9956	8618	7279

Dilution factor available in the White Nile during the production season

$$= \frac{\text{River flow rate}}{\text{Flow of factory waste water}} = \frac{\text{QR. F}}{\text{QF. F}}$$

$$\text{Dilution Nov.} = \frac{88.5 * 10^6 \text{ m}^3/\text{d}}{5976 \text{ m}^3/\text{d}} = 14809$$

$$\text{Dilution Dec.} = \frac{76 * 10^6 \text{ m}^3/\text{d}}{5976 \text{ m}^3/\text{d}} = 12717$$

$$\text{Dilution Jan.} = \frac{56 * 10^6 \text{ m}^3/\text{d}}{5976 \text{ m}^3/\text{d}} = 9370$$

$$\text{Dilution Feb.} = \frac{55 * 10^6 \text{ m}^3/\text{d}}{5976 \text{ m}^3/\text{d}} = 9203$$

$$\text{Dilution M.} = \frac{59.5 * 10^6 \text{ m}^3/\text{d}}{5976 \text{ m}^3/\text{d}} = 9956$$

$$\text{Dilution Ap.} = \frac{51.5 * 10^6 \text{ m}^3/\text{d}}{5976 \text{ m}^3/\text{d}} = 8617$$

$$\text{Dilution May} = \frac{43.5 * 10^6 \text{ m}^3/\text{d}}{5976 \text{ m}^3/\text{d}} = 7279$$

The average dilution factor across the production season is = 10278

So if we exclude the interactions between the contaminants in the waste water and the high concentration at the disposal point and the low flow stagnation within the Al - jassir canal. The immediate effect and accumulative effect on the aquatic life

The available dilution factor in the river is sufficient to reduce the degree of contaminants in the White Nile to an acceptable level [Abdeen Mohamed Ali Salih, Mohamed Ahmed Adem khadam, 2001].

#### IV. CONCLUSION

The discharges of industrial sewage and irrigation effluent are highly polluted in terms of Phosphate content, Turbidity, Chemical Oxygen Demand, Biochemical Oxygen Demand and Color.

Household members around the Assalaya Sugar Factory use water for drinking from the main canal without treatment, and sometimes they withdraw surplus irrigation water directly.

The study reflected strong correlation between the Industrial sewage and irrigation effluent disposal and the spread of water related diseases.

The study recommended Assalaya Factory should redesign and reconstruct its present wastewater treatment plant because of its inefficiency and should adopt the cleaner

production principle through waste recycling and reuse, thus minimizing the quantity of the generated waste and consequently its impact on the environment.

**The study recommends:**

- Assalaya Factory should redesign and reconstruct its present wastewater treatment plant because of its present inefficiency.
- The surplus irrigation water should be reused in irrigation and not be disposed into the Al - jassir canal.

**REFERENCES**

- [1] Abdeen Mohamed Ali Salih, Mohamed Ahmed Adem khadam ,(2001), Water supply in Sudan, NCR , Sudan.
- [2] Alexander P. Economopoulos, (1993). Assessment of sources of air, water, and land pollution: a guide to rapid source inventory techniques and their use in formulating environmental control strategies. Part 1. Geneva: World Health Organization.
- [3] American Backflow Prevention Association (ABPA). 2000 Survey of State and Public Water System Cross-Connection Control Programs. Washington, U, S.A
- [4] Boon, C. J., (1990) "Environmental problems ", Part 1 & part 11. University of California
- [5] Brassard, PG (1996) Wetlands and Water Pollution Boston Coll. Environ. AFF. Law rev. vol. 23, no. 4, pp. 885 – 919.
- [6] Dix, H. M., (1981). Environmental pollution. John Wiley & sons, Toronto. Pp 54 – 56
- [7] Elhaj, K. O. (1984).“ , a technical study on the industrial waste in Port Sudan city" M. Sc. Thesis: University of Khartoum. Sudan
- [8] Elhassan, B.M and Rabih A, (2012), Assessment of wastewater treatment plants in Assalya and Sennar Sugar Factory, Sudanese sugar company..
- [9] FAO – Swedish Defense research agency (May 2004). Sudan Environmental and Health Risks to Personnel to be deployed to Sudan, pre-deployment assessment. Sudan office.
- [10] Idris, E., (1983). "Industrial production in the Sudan: in industrial develops strategies & policies for developing countries" The fourth general conference of UNIDO.
- [11] Mackenzie, (1996), the Ecosystem Island Press, Washington, DC (USA), pp. 240 – 253.
- [12] Mac Donnell, LJ (1996). Water Quality Land Water Law rev. vol. 31, no. 2, pp. 329 – 348.
- [13] Ministry of industry & Ministry of finance (1995). "Study of the identification of Rehabitations needs has selected Industrial sub sector". Volume 1, Republic of Sudan.
- [14] Mohamed, A.A., (1999). "The effect of industrial wastes on respiratory system" A comparative study, M. Sc. Thesis: University of Khartoum.
- [15] Murray Spiegel, (2004), Statistics, Schaum series Spiegel M R Schauams outline of statistical.
- [16] Park, K., (1997). "Environmental and health In: preventive & social medicine", 15th ed, India pp 508 – 515.
- [17] Roghaia, A.A.(1989) “Assessment of industrial liquid waste management in the Omdurman industrial area” M.Sc. Thesis: University of Khartoum.
- [18] Shakkak, N. B. (1985). "Assessment of Industrial Pollution – study case in Port Sudan Coast" M. Sc. Thesis: University of Khartoum. Sudan
- [19] Sudanese Standards and Metrology Organization SSMO (2007). The maximum allowed code for the different materials that may affect the consumer acceptance of water. Ministry of Presidency of the Council of Ministers. – Sudan.
- [20] Tilak, K.S., Janardhana Rao, N.H. and Lakshmi, J. (1991). Effect of pesticides mixed in different ratios to the freshwater Lareo rohita. J. Ecotoxicol. Environ. Monit.1: 49-52.
- [21] UNEP teams. (2010). Industry and the environment in the Sudan. UNEP publication.
- [22] United Nations development programmed (UNDP) (1994) Report, "Development co-operation" UNDP. Report, Khartoum, Sudan.
- [23] WHO, (2006), guideline for drinking- water quality first addendum third edition. Geneva
- [24] World Bank. (1995). “Industrial Pollution Prevention and Abatement: Sugar Manufacturing”, Draft Technical Background Document, Environment Department, Washington.
- [25] WHO, (1995). Solid waste & health No. 5 world health organization, Regional office for the Eastern.