

**EFFECT OF SOAP INDUSTRY EFFLUENTS ON SOIL AND
GROUNDWATER IN ALBAGEIR AREA**

BY

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Thesis Submitted in Partial Fulfillment of the Requirements of
Master Degree of Science in Environmental Studies.

Institute of Environmental Studies

University of Khartoum

(2004)

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Acknowledgements

I would like to express my deepest thanks and gratitude to my supervisor, Dr. A. H. El Nadi, for his kind guidance, keen supervision, support, assistance and mostly for his utmost patience. Especial thanks are extended to all the staff of the Institute of Environmental Studies and the staff of the Hydro biological Research Unit.

Thanks to Dr. S. A. Saad from the Environment and Natural Resources Research Institute and Dr. M. Y. Babikir for his help with the chemical analyses.

I am so grateful to all those who helped by their valuable knowledge and precious time, make this study possible.

Abstract

This study investigates the effect on soil and groundwater produced by the effluent from soap industry discharged from Alsheikh Mustafa Alamin (SMA) factory, in Albageir industrial area, located 45 Km south of Khartoum.

Soil samples were taken from the periphery of the effluent pond and from 25&50 cm depths from pits at different distances from the pond. The samples were analyzed for the following chemical and physical characteristics pH, EC, sodium, chloride ions and their grain size, in order to investigate any possible soil degradation. The results showed that there is an increase in soil salinity and sodicity resulting from the improper discharge of the liquid waste, and from lack of treatment before the discharge. Hence, there are definitive signs for soil degradation in the study area, which could reach a high magnitude in the long run. This situation could be rectified by adopting updated techniques for treatment and disposal of effluent, and by regular inspection, by the authorities in order to make sure that the regulations are not violated.

Chemical and physical analyses of groundwater samples showed no signs of pollution. However, if the disposal practices are not revised, the possibility of pollution in the near future is likely to occur.

A package of measurements is proposed in order to curb the impact of the industry on the environment.

المخلص

اهتمت هذه الدراسة بأثر صناعة الصابون فى مصنع الشيخ مصطفى الأمين بمنطقة الباقير 45 كلم جنوب الخرطوم على التربة و المياه الجوفية بالمنطقة.

تم أخذ عينات من التربة من حافة حوض المخلفات و من أعماق مختلفة لحفر اختبار أعدت على مسافات مختلفه من الحوض. أتضح من تحليل هذه العينات أن هناك زيادة واضحة فى ملوحة و صودية التربة نتجت عن التخلص غير الرشيد من مخلفات تلك الصناعة مباشرة دون أى معالجة. هذه النتائج تؤكد تماما التدهور الذى أصاب التربة فى تلك المنطقة و الذى سوف يتزايد بمرور الزمن اذا اتبعت نفس أساليب التخلص من المخلفات. يمكن معالجة هذا الوضع بتطبيق تقنيات حديثة تشمل المعالجة ثم التخلص السليم من تلك المخلفات مع الرقابة الدورية بواسطة الجهات المسؤولة. اتضحت سلامة المياه الجوفية التى تم تحليلها من أى تلوث فى الوقت الحاضر, ولكن الاستمرار فى طريقة التخلص الحالى للمخلفات قد تضر مستقبلا بالمياه الجوفية خاصة و أنها المصدر الوحيد لمياه الشرب فى المنطقة.

سجلت الدراسة عدة مقترحات نأمل من تبنيها تقليل الأثر السالب لصناعة الصابون فى منطقة

الباقير.

Chapter one

Introduction

1.1 General :-

Since the start of the industrial revolution in the late 19th century, excessive industrialization has resulted in excessive wastes especially in the developed world.

Industrial waste management practice has primarily involved the disposal and use of either on- site or off- site landfill. Industrial wastes are often disposed off using the typical so- called sanitary landfill. Many of those land disposal sites are not designed or operated to handle the industrial residues and are often not run even according to sanitary landfill practices. As a result, leaching of harmful components from those wastes, if not properly contained or controlled, will migrate out of the landfill site into the underlying soil, changing its characteristics affecting vegetation and contaminating groundwater or nearby surface water. Pollution is a progressively more serious problem depending on the raw material used , the fuel, the process and the type of pollution control measures applied in the specific industry.

Improvement of environmental quality is a recent phenomenon which had begun only in the late 1960s was largely confined to the

economically advanced countries. The first United Nations conference concerning the protection of the environment was held in Stockholm in 1972. The conference recommended development without harm to the environment. Later, the Nairobi conference was held in 1980 followed by the Earth Summit conference in Rio de Janeiro in 1992. The last gathering was held in Johannesburg, 2002 on sustainable development & the environment. (Kolaczowski & Crittenden, 1987; Abdelmagid, 1982).

1 . 2 Statement of The Problem :-

Albageir industrial area is located at Latitude 15° 20', Longitude 32° 43', in the Gezira state, central Sudan. It lies in the Elkamlin province and is approximately 45km south of Khartoum, on the western side of Khartoum-Medani-Port-Sudan Highway.

The area constitutes a complex of industries including Albageir Ginng Factory on its southern border, The Kuwaiti Sudanese Company in the north and Albageir Agricultural Scheme on its wesern side. Khartoum-Medani-Port-Sudan high way bordering the area from the east. It is composed of different types of industries. It was thought of as a solution for the lack of land to be allocated for industrial areas in greater Khartoum, beside other reasons such as its

easy accessibility, availability of electrical power and the achievement of development of rural areas.

The first ever to start production was Albageir Ginning mill in 1974. There is no central point for industrial effluent collection. The problem of the industrial waste in the area increased because all industries discharge their wastes as it is without treatment. Waste water is discharged from the factories into ponds. These ponds are the main source of soil pollution. Leachate from the ponds may penetrate deep into the soil causing profound changes in the soil constituents and groundwater quality. Moreover, the number of the factories is on the increase and that means more hazardous waste production and more negative impact on soil, vegetation and groundwater. This study focuses on the possible deleterious impact of the soap factory on the environment.

Table 1 : Type & No. of Unit Industries in Albageir Area (Mohamed,1999).

Factory Type	No. of Units	Pretreatment Method Practiced	Distance of Point of Discharge from Factory.
Food Industry	8	No Method	10-15m
Oil and Soap	12	No Method	5-20m
Starch and Glucose	1	1-Chemical Treatment 2-Biological Treatment By Stabilization Ponds 3-The Untreated Liquid Waste is Collected By Tankers from Factory and Discharged in an Open Area	3km
Textile	1	No Method	300 m
Tannery	1	1-Filtration 2-Aeration in a Series of 4 Tanks 3-Chemical Oxidation 4-Mechanical Process to Separate Liquid from Solid	300 m
Pharmaceutics	1	No Method	Everywhere

Most of the factories do not have adequate waste water treatment facilities. The practice generally followed is to discharge these wastes on land. Improper planning for treatment and disposal of industrial waste water in this area together with lack of regular health inspection left the choice for every factory to have its own system of disposal.

In this study, the industry of soap represented by Elsheikh Mustafa Alamin Factory (SMA) is chosen to show its effluent effect on groundwater & soil. The Factory started production in 1982, it occupies an area of 88 feddans. The main processing lines are, edible oil and soap manufacture. The latter consists of a toilet and laundry soap line. At the time of study the laundry soap production reached 6000 tons/year and the toilet soap 2000 tons/year. The establishment is the largest in the area. The main sources of liquid waste are the wash down process, oil spillage, cooling water, oil refining, oil neutralization, wash down of soap, purification leakage of alkalis and other salt solutions used in the process, fatty acids spillage, oil spills and domestic use of water in the factory and the residential area inside the campus. In the area. There are three sites for industrial waste water disposal, one of the sites is used by (SMA) establishment. It is composed of four stabilization ponds one kilometer away from the factory each is of 100m*100m*2m. They are used when the ponds inside the plot are full.

Tankers discharge the waste water daily in those ponds. Sometimes the waste water is discharged just outside the western side of the factory which is an open empty area. This goes on every day. The liquid waste quantity per day is 120 meter cubed and the expected composition is caustic soda and soap oil (Murtada, 2000) When the level of the water in the ponds becomes low, new waste water is pumped into them. When they leave the ponds to dry they scrape the beds and dump the collected cake on the banks.

Table 2 : (SMA) Products (Marouf,1987).

Raw Materials	Type of Industry	Substances Added	Final Products
NaOH,Fats (Stearine)+Salts	Soap	Sodium Silicate, Sodium Carbonate, Chalk Powder,Nacl	Soap(Toilet &Laundry)and Glycerin as By Product
NaOH,Cotton seed, Ground nut,Sesame.	Oil	NaOH	Refined Oil,SoapStock&Fatty Acids as By Product
Plastic Granules	Plastic	- - -	Plastic Cans &Bottles

Table 3 : (SMA) Liquid waste characteristics (Murtada, 2000).

Plant Parameter	SMA Pipe	SMA Pond	SMA Soap line	SMA Boiler
pH	10.2	9.8	9.6	-
BOD	150	285	115	-
COD mg/L	315	486	270	-
S.S mg/L	2500	3800	1300	-
TDS mg/L	300	420	220	-
Oil&Grease mg/L	2100	2600	1700	-
Cr mg/L	-	-	-	0.032
Pb mg/L	-	-	-	0.108
Temperature		34C		

1.3 Previous Work :-

Although a number of M.Sc. theses have been written on the environmental problems of industry in the Sudan, the first study in the area of Albageir was carried out by Magzoub in 1986 in order to assess the environmental pollution of liquid waste disposed of in the area and to propose solutions to the problem. Comprehensive laboratory analyses of liquid waste was carried out to cover such parameters such as the Biochemical Oxygen Demand (B.O.D), Total Dissolved Solids (TDS), Suspended Solids (SS), Hydrogen Ion Concentration (PH), Electrical Conductance (EC), Hydrogen Sulphide (H₂S), and Ammonium (NH₄) and Phosphate (PO₄). The experimental results showed that almost all the industrial effluents defy the accepted levels of the industrial pollution control. As for the effect of industrial waste dumped upon soil, a study was carried out by Babikir (1998) in Khartoum north industrial area. The Laboratory analyses have indicated that there are signs of soil pollution resulting from improper disposal of industrial waste. The computer mapping of some toxic elements showed trends of high levels of pollution in the industrial area. It shows that soil pollution by industrial waste in Khartoum north is alarming and it needs the attention of the authorities. An M.Sc. thesis on the Chemical characteristics and quality of groundwater in Khartoum Province and northern Gezira, was carried out by Farah (1993). He found that the highest concentration of nitrates in two wells was attributed to their

presence in Albageir industrial area. The relatively high nitrate content of the water from these wells is probably influenced by organic pollution, as dumping of wastes near the industrial area is often practiced in shallow pits or directly on the ground surface. (Farah,op.cit).

1 . 4 Objectives of the Study :-

The main objectives of this study in Albageir area are:-

- 1 - To investigate the effect of waste sludge of industrial origin produced by soap industry on soil properties and groundwater.
- 2 - To identify the magnitude of pollution dispersion on soil and water.
- 3 - To develop a correlation, if any, between the different parameters.
- 4 - To assess the situation and to recommend possible remedial measures.

1 . 5 Hypothesis :-

Different industries in Albageir use a very large number of raw materials to manufacture a broad range of products. Liquid waste from those products include, inorganic salts, acid and/or alkalis, organic matter, suspended solids. If those pollutants are disposed untreated on land, they will cause ecological disruption by changing soil characteristics and contaminating groundwater.

1 . 6 Materials & Methods :-

Groundwater & soil samples were taken from the site of waste water disposal of the soap factory in Albageir industrial area. Global Positioning System (GPS) was used to locate & map the various sample sites. Using physical and chemical parameters such as , Biochemical Oxygen Demand (BOD), Hydrogen Ion Concentration (pH), Electrical Conductance (EC) , Chloride (CL) , Nitrate (NO₃), Ammonia (NH₃) , Sodium (Na) , Potassium (K) , Chromium (Cr) , Calcium (Ca) , Magnesium (Mg) , were determined at the Hydro biological Research Unit, the Institute of Environmental Studies. and at the Environment & Natural Resources Research Center, Ministry of Sciences & Technology. The description of each analytical method is given in chapter (3).

CHAPTER TWO

INDUSTRIAL WASTE

2 . 1 Types of industrial waste :-

No activity, whether a manufacturing process, a residential activity or an agricultural operation transforms 100 percent of its inputs into desired products and services . There is always something 'left over', i.e. residues ,which must be disposed of in some way or another. Most often disposal is made into one or more of the environmental media: water, air or land.

Industrial wastes are of different characteristics. They vary considerably in composition and concentration, from an industry to the other and even within the same type of industry. Industrial wastes include:-

- 1 - Solid waste,
- 2 - Liquid waste,
- 3 - Gaseous waste,

the study and knowledge of which is very important in order to plan measures for management and control against their harmful effect (Mohamed,1999 ; Abdelmagid, 1982) .

2 . 1 . 1 Industrial solid waste :-

Industrial solid waste is defined by (Technobeglous et al,1977) as all wastes resulting from industrial activities that are

normally solids discharged as useless or unwanted. Those wastes include any discharged

industrial material resulting from an industrial operation or establishment with the exception of dissolved or suspended solids in water. The quantity and composition of industrial solid wastes vary significantly from place to place as well as among industries in the same site and even among industrial plants in the same industrial category (Mohamed,1998).

2 . 1 . 2 Industrial liquid waste :-

Industrial liquid wastes are defined by (Adam ,1976) as the liquid discharges from an establishment that prepares any material or article for the market . The liquid waste differs from the water supply received by the establishment and used in its operation (Mohamed,1998).

Liquid wastes are always hazardous to the environment. Depending on their type and quality as well as time period, they may include all or some of the following pollutants: inorganic salts, acid and/or alkalis organic matter, suspended solids and liquids, heated water, colour, toxic chemicals, microorganisms and radioactive materials.

2 . 1 . 3 Industrial gaseous waste :-

Industrial air pollution is defined as the gaseous or emission uniquely associated with manufacturing processing of goods (Mohamed,1998).The industrial waste gases do not have common

properties depending on the raw material used ,technology applied and the final products obtained. The gases may contain carbon, hydrogen compounds and other non- carbon compounds such as nitrogen oxides and sulphur dioxide and other particulate (Abdelmagid1982).

2 . 2 Industrial waste characteristics :-

The characteristics of undesirable waste depend on the nature of the industry and the projected uses of the water of the receiving stream or the uses of land. Various waste constituents summarized below may have to be removed before discharge.

2 . 2 .1 Soluble organics :-

They cause depletion of dissolved oxygen . Since most receiving waters require maintenance of minimum dissolved oxygen, the quantity of soluble organics is correspondingly restricted to the capacity of the receiving water for assimilation

2 . 2 . 2 Suspended solids :-

The deposition of solids will impair the normal aquatic life of the stream .Sludge blankets containing organic solids will undergo progressive decomposition resulting in oxygen depletion and the production of noxious gases.

2 . 2 . 3 Trace organic compounds :-

The discharge of phenol and other organic compounds into a receiving water that is used as a source for potable water will

result in tastes and odors in the water. If these contaminants are not removed before discharge, additional water treatment will be required.

2.2.4 Heavy metals :-

Some of the heavy metals like, Mercury, Cadmium, Chromium, Lead, Copper and the Cyanides, usually have prescribed limits for discharge, since they are deleterious to aquatic life.

2.2.5 Colour & Turbidity :-

They present aesthetic problems even though they may not be particularly deleterious for most water uses.

2.2.6 Nitrogen & Phosphorus :-

When effluents are discharged to lakes, ponds and other recreational areas, the presence of nitrogen and phosphorus is particularly undesirable, since they enhance eutrophication and stimulate undesirable algal growth.

2.2.7 Refractory substances resistant to biodegradation :-

These may be undesirable for certain water quality requirements. For instance, alkyl benzene sulphonate from detergents is substantially non degradable and frequently leads to a persistence of foam in the water course.

2.2.8 Oil & Floating materials:-

These produce unsightly conditions and in most cases are restricted by regulations.

2 . 2 . 9 Volatile materials

Hydrogen sulphide and other volatile materials will create air pollution problems under certain chemical environment. The volume & strength of industrial wastes are usually defined in terms of units of production e.g. gallons/ton of pulp. The statistical distribution of variation in characteristics in any one plant there will be a statistical variation in waste flow characteristics. The magnitude of this variation will depend on the diversity of products manufactured , the process operations contributing to waste production and on whether the operations are batch or continuous. Good house- keeping procedures in order to minimize dumps & spills will reduce the statistical variation (Eckenfelder,1960).

The stability of a sludge ,as measured by its toxicity is a function of the method of disposal and each case must be evaluated separately. If a sludge is to be disposed of on farmland, for example, we would normally look for such characteristics as high concentration of heavy metals ,high oxygen demand, abnormally high or low pH, or unsafe level of pathogenic organisms.(Vesilind,1980).

The disposal of waste is either achieved through landfill or lagoons. The disposal of hazardous waste by landfill is one of the main methods of disposal in many countries. In fact, the continued use of landfill , especially chemical landfill of hazardous waste disposal is generally an accepted practice in many countries .However, differences in geology,

hydrobiology, topography, climate & population density in the various countries will probably prevent the development of a single universally acceptable scheme for hazardous waste landfill management . Among the developed countries there is a common consensus that the most important potentially harmful result of hazardous waste landfill is the pollution of water resources , particularly ground water. However, where surface water and groundwater pollution incidents have occurred ,they have usually been due to problems of site selection or operational inadequacies rather than to any basic unsuitability of landfill as a disposal route .While many hazardous wastes can safely be disposed properly selected and managed sites with minimal impact of the environment, landfill can't be regarded as suitable for all wastes (Sues & Huismans,1983).

Lagoons are simply large holding basins with earth embankments. They are designed either as temporary holding basins or as a means for ultimate sludge disposal . The latter are described as permanent lagoons, though they are not widespread .Lagooning is almost always a temporary holding ,given cheap land and space available for the construction of big holes (Vesiland,1980).

2 . 3 Industrial development in Sudan :-

Industry in Sudan started by the turn of the last century. Before the second World War, it was in the handcraft stage, and the colonial policy in Sudan was to export agro- industrial products. As

Sudan is considered to be an agricultural country, industries were existing in a very low density and the country's economy depends on agricultural products and natural resources. During the war it became clear that the country should start programmes for self sufficiency in certain commodities. The political independence year (1956) could be taken as the gate-way for real industrialization in Sudan. The first step was the approval of the Commission Act of 1956 which was issued to encourage the local and foreign capital investment in industry. Expansion of cotton production was followed by the construction of spinning factories .Sugar industry began at Elguneid in 1961 and at Algirba in 1963. Then the first tannery was established in Khartoum ,followed by 5 dispersed food processing plants. Most of the industries in the Sudan are located in urban areas except the industries that are attracted to their source of raw material. Khartoum, Khartoum North ,Omdurman, Port-Sudan, Maringan, and Albageir are 6 examples of industrial complexes in urban areas Therefore the Sudanese industries with their various activities could create serious waste problems of local nature.

The major goal of industrialization is to achieve economic development and improve prospects for human well being. But if proper abatement technology is not used ,industry becomes a major source of water, soil and air pollution. The satisfactory disposal of industrial effluent is a major problem ,causing growing concern to

public health authorities in Sudan. Generally most of the industries in the Sudan, if not all, release and discharge wastes which include gases ,liquids & solids of different chemical and physical properties All these wastes are discharged into the atmosphere, water bodies and land with different levels of treatment and in most cases- with rapid population and industrial growth -without treatment.This ,together with other factors have created serious wastewater and solid waste collection and disposal problems for the major cities of Sudan.

(Younis & EL Dawi,1990).



Fig.1 Satellite image of the study area showing SMA factory as a blue square in the middle and the Blue Nile to the northeast of the factory (Kindly provided by Babikir, M. Y., Landscape & Remote sensing Department, Goettingen University, Germany)

Chapter Three

Laboratory Analysis

3.1 Materials :-

Five field trips were carried out during the period from November 2003 to January 2004 in order to survey the study area and locate and collect the required samples. The selection of wells and the site of soil samples was done according to the dispersion aureole of the effluent from Elshiekh Mustafa Alamin (SMA) effluent pond.

Using the Global Positioning System (GPS), the location of the five wells is shown on Table 4.

Table 4 : Location of wells.

No	Name	Latitude	Longitude
1	Shoaib flour mills	15° 20' 9.09"	32° 44' 49"
2	Shakour	15° 19' 8.94"	32° 44' 8.38"
3	Hussein	15° 19' 18.6"	32° 42' 8.67"
4	Alamin alberair	15° 18' 7.57"	32° 43' 43.9"
5	Caustic soda factory	15° 20' 51.0"	32° 43' 17.5"

Water samples were collected from the five wells in plastic bottles and one waste water sample was taken from the effluent pond . Nine soil samples were taken as follows :- (See Fig.2)

-One surface sample (S0) from the western periphery of the effluent pond.

-Two samples (S1,S2) from a pit (A) 25 m from the effluent pond, one at a depth of 25 cm (S1) & the other at a depth of 50 cm (S2).

-Two samples (S3,S4) from a pit (B) 50 m from the effluent pond , one at a depth of 25 cm (S3) & the other at a depth of 50cm (S4).

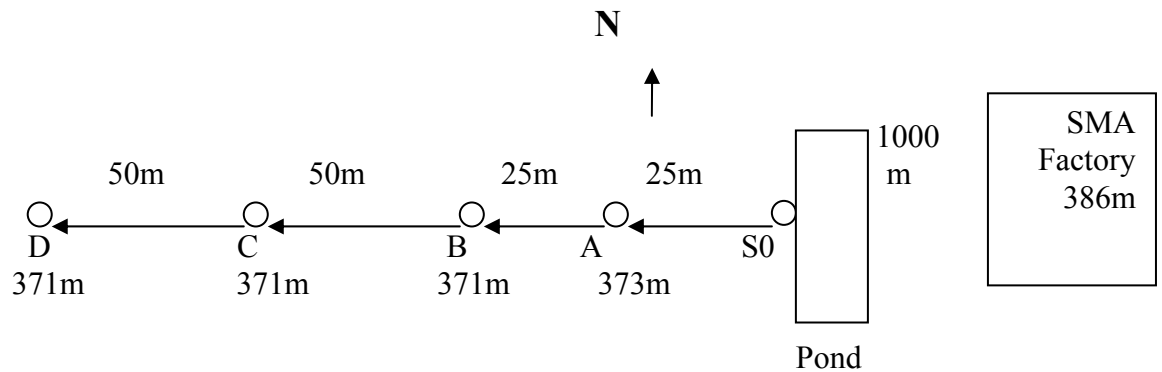
-Two samples (S5,S6) from a pit (C) 100 m from the effluent pond, one at a depth of 25 cm(S5) & the other at a depth of 50 cm (S6).

-Two samples (S7,S8) from a pit (D) 150 m from the effluent pond , one at a depth of 25 cm (S7) & the other at a depth of 50 cm (S8).

Table 5 : Location and distance of soil samples from the effluent pond

No	Soil sample	Pit No.	Distance from pond (m)	Elevation above sea level (m)	Latitude	Longitude
(SMA) pond	S0		0	386m	15° 20' 28"	32° 44' 45"
1	S1,S2	A	25m	373m	15° 20' 40.2"	32° 43' 9.34"
2	S3,S4	B	50m	371m	15° 20' 40.0"	32° 43' 9.29"
3	S5,S6	C	100	371m	15° 20' 39.4"	32° 43' 9.01"
4	S7,S8	D	150	371m	15° 20' 38.7"	32° 43' 8.74"

Fig . 2 Distances (not to scale) and elevations in meters above sea level of surface soil samples from the effluent pond of the SMA factory.



It is clear from the satellite image (Fig. 1) that the site is almost devoid of vegetation except for some scattered bushes, mainly the Mesquite (Prosopis chilensis) not less than 300 meters away from the pond surroundings . However, the study area is surrounded by farms from the west, east and north. The crops grown are usually fruits, vegetables and forage.

Classical analytical methods were applied for the determination of water quality by analysing the chemical and physical parameters. The analyses were carried out at the Hydro Biological Research Unit, Institute of Environmental Studies (I.E.S), University of Khartoum.

The parameters include :-
 Hydrogen ion concentration (pH).
 Electrical Conductance (EC).

Major cations: sodium, potassium, chromium.

Major anions: chlorides, nitrates, ammonia.

Organic compounds: Biochemical Oxygen Demand , (BOD).

The chemical analyses of soil include : EC, pH, the sodium cation and the chloride anion in order to determine the soil sodicity and salinity. These analyses were carried out at the Environment and Natural Resources Research Center, National Research Council, Ministry of Sciences and Technology.

The separation of soil samples into sand and silt was carried out at the Sedimentology Laboratory, Geology Department, Faculty of Science, University of Khartoum.

3 . 2 Methods :-

3 . 2 . 1 Physical and chemical analyses of groundwater and soil samples :-

3 . 2 . 1 . 1 Hydrogen ion concentration (pH) :-

It is the most important parameter in water and waste water analysis, since it basically controls all chemical and biochemical reactions. The determination and control of the pH is very important, especially in the neutralization processes of industrial waste. It is measured by a pH meter . Accordingly water can be classified into:

Neutral water (pH = 7)

Acidic water (pH < 7)

Alkaline water (pH > 7)

The results of pH measurements for water samples (Table 6) range from 7.2 in well No. 3 to 7.8 in wells No. 1 and 4.

The results of pH measurements from the extract of the soil samples (Table7) range from 8.2 in sample No. S6 (Pit C) to 10.3 in sample No.S1 (Pit A)

3.2.1.2 Electrical Conductance (EC) :-

It is the measurement of dissolved ions using a conductivity meter.

The EC measurements in (d S/m) range in water samples (Table 6) from 0.22 in well No. 5 to 0.45 in well No. 4.

The EC measurements for soil samples (Table 7) range from 4.4 in sample No. S7 (Pit D) to 13.3 in sample No. S2 (Pit A).

3.2.1.3 Biochemical Oxygen Demand (BOD5) Test:-

It is the measurement of the amount of oxygen consumed by bacteria whilst oxidizing organic matter under aerobic conditions. The test determines the approximate quantity of oxygen that will be required biologically to stabilize the organic matter present at 20°C and for the standard time which is usually five days (Abdelmagid, 1986) .

The level of BOD considered desirable by the WHO is 10 mg / L.

The values of BOD for water samples (Table 6) range from 1.4 mg / L in well No. 4 to 5 mg / L in well No. 2 .

Table 6 : Chemical analyses of water samples from 5 wells in the study area (Water table between 20 – 23 m deep & elevation above sea level between 367.5 - 370 m).

Parameter	BOD mg/L	Cr mg/L	Nitrates mg/L	EC dS/m	NH3 mg/L	pH	Na mg/L	K mg/L	Cl mg/L
Well									
1	2	0.06	12.4	0.38	0.4	7.8	25	2	35.5
2	5	0.05	10.2	0.42	0.6	7.4	60.2	2.3	35.5
3	4.4	0.04	12.8	0.38	0.4	7.2	62.4	2.9	25.5
4	1.4	0.04	14.1	0.45	0.3	7.8	24	6.5	24.1
5	4	0.05	15.9	0.22	0.3	7.4	12.5	1.8	14.1

3.2.1.4 Measurements of Ammonia (NH₃) , Nitrates (NO₃) & Chromium (Cr) :-

This is achieved by the direct reading from the spectrophotometer (Model Hach DR/2000) , using different wave lengths according to the programme accompanying the instrument. The Ammonia measurements for water samples (Table 6) vary from 0.3 mg / L in well No. 4 to 0.6 mg / L in well No. 2. The nitrate measurements for water samples (Table 6) vary from 10.2 mg / L in well No. 2 to 15.9 mg / L in well No. 5.

The chromium measurements for water samples (Table 6) vary from 0.04 mg/L in wells No. 3 & 4 to 0.06 mg / L in well No. 1.

3.2.1.5 The Chloride Test:

The chloride anion is determined by titration of water sample against silver nitrate of known normality, using potassium chromate as an indicator. The following formula was used for the calculation of the chloride content in the water samples:-

$$\text{Chloride content (mg/L)} = \frac{(A - B) * N * 35.450 * 1000}{V}$$

Where A = Titrant (ml).

B = Blank (ml).

N = Normality of Silver Nitrate.

V = Volume of sample(ml).

The chloride measurements for water samples (Table 6) vary from 14.1 mg/L in well No. 4 to 35.5 mg/L in wells No. 1 and 2.

The following formula was used for the calculation of the chloride content in the soil samples :

$$\text{Chloride content (meq / L)} = V * N * 1000 / V1$$

Where V = Volume of silver nitrate (ml) .

N = Normality of silver nitrate.

V1 = Volume of sample (ml)

The chloride measurements for soil samples (Table 7) vary from 27 meq /L in soil sample No. S7 (Pit D) to 135 meq/L in soil sample No. S2 (Pit A) .

3 . 2 . 1 . 6 Determination of sodium & potassium cations :-

Sodium and potassium cations for both water and soil samples are measured by Atomic absorption spectrophotometry . The sodium measurements for water samples (Table 6) vary from 12.5 mg/L in well No. 5 to 62.4 mg/L in well No. 3. The potassium content for water samples (Table 6) vary from 1.8 mg/L in well No. 5 to 6.5 mg/L in well No. 4 . The sodium determination for soil samples (Table 7) vary from 34.7 meq/L in soil sample No. S7 (Pit D) to 102.1 meq/L in soil sample No. S2 (Pit A) , whereas the potassium measurements for soil samples vary from 0.048 meq/L in soil sample No. S7 (Pit D) to 0.1 meq/L in soil sample No. S3 (Pit B) .

Table 7: Chemical analyses of the soil samples in the study area.

Soil Samples	Depth (cm)	pH	EC d S/m	Na meq/L	CL meq/L	K meq/L	Ca&Mg meq/L	ESP	SAR
S1	25	10.3	12.55	72.8	59	0.07	52.7	17.7	14.3
S2	50	10.2	13.34	102.1	135	0.06	31.3	27.9	25.8
S3	25	9.2	10.85	71.7	51	0.10	35.7	20.1	16.8
S4	50	8.5	9.20	63	88	0.09	29	20.1	16.5
S5	25	9	11.85	65.2	45	0.07	53.3	15.9	12.6
S6	50	8.3	6.78	41.3	35	0.09	26.5	14.7	11.5
S7	25	8.4	4.4	34.7	27	0.05	9.3	19.4	16
S8	50	8.2	6.21	39.1	41	0.09	23	14.7	11.5
S0	surface	9.7	61.6	434.8	417	1.9	42.8	59	94.5

3 . 2 . 1 . 7 Determination of Sand & Silt in the soil samples:-

40 gm were taken from each sample and 200 ml of water were added. After shaking for 8 hours the samples were wet sieved with a (0.045 *0.063 mm) sieve. the remaining sand was weighed and the percentage of sand and silt was calculated.

The percentage ratio of sand in the soil samples (Table 8) ranges between 53.8% in the soil sample No. S2 (Pit A) to 77% in the soil sample No. S6 (Pit C) , while the percentage ratio of silt&clay (Table 8) varies from 23% in the soil sample No. S6 to 46.2 % in the soil sample No. S2.

3 . 2 . 1 . 8 Determination of calcium and magnesium cations :-

Calcium and magnesium cations are measured by titration of soil sample extract against Ethylenediaminetetra - acetic acid (EDTA) with addition of ammonium chloride as a buffer, using Eriochrome Black T (E B T) as an indicator. 0.5 ml of the extract were taken and diluted to 20 ml with distilled water then titrated as mentioned above using the following formula.

$$\text{Ca + Mg meq / L} = \text{N * V * Dilution factor / Volume of sample}$$

N = Normality of EDTA

V = Volume of EDTA.

Calcium and magnesium measurements for the soil samples (Table 7) vary from 9.3 meq / L in the soil sample No. S7 (Pit D) to 52.7 meq / L in the soil sample No. S1 (Pit A) .

Table 8: Mechanical analyses of the soil samples in the study area .

Soil Samples	Depth (cm)	Sand%	Silt & clay%
S1	25	63.9	36.1
S2	50	53.8	46.2
S3	25	62.2	37.8
S4	50	69.8	30.1
S5	25	70.9	29.1
S6	50	77	23
S7	25	69.5	30.5
S8	50	57	43

3 . 2 . 1 . 9 The Sodium Adsorption Ratio (SAR) :-

It is a term suggested by the United States Salinity Laboratory Staff (1954) and is adopted worldwide to express the sodium hazard. The SAR is the tendency of water to replace or exchange calcium and

magnesium ions ,adsorbed by the soil particles with its dissolved sodium. This process may give rise to reduction of permeability and hardening of the soil.

The SAR is defined as the ratio of sodium ion concentration in the soil solution to half the square root of the total divalent ion concentration of calcium plus magnesium .

The values of SAR (Table7) vary from 11.5 in the soil sample No. S6 (Pit C) to 25.8 in the soil sample No. S2 (Pit A) .

3 . 2 . 1 . 10 Exchangeable Sodium Percentage (ESP) :-

It is the percentage ratio of sodium ions balancing the charge of the clay surface to the divalent ions on the clay surface . It expresses the sodicity of soil when it exceeds 15% . It can be calculated from SAR by the following equation:

$$ESP = 100 (0.015 SAR) / 1 + 0.015 SAR .$$
 The values of ESP (Table 7) vary from 14.7 in the soil samples No. S6 (Pit C) & S8 (Pit D) to 27.9 in the soil sample No. S2 (Pit A)

The results of ESP (Table7) vary from 14.7 in soil sample no. S6 (Pit No. C) to 20.6 in soil sample no. S3 (Pit No. B) .

Table 9 : Correlation Coefficient and P values (Calculated significance level) for The 8 Soil Samples.

Cell Content :- (Correlation coefficient and P value).

	Na	EC	pH	ESP	SAR	Distance
Depth	0.00655	_-0.167	_-0.259	0.129	0.160	0.000
	0.988	0.692	0.536	0.761	0.706	1.000
Na		0.920	0.842	0.768	0.773	_-0.862
		0.00121	0.00872	0.0261	0.0244	0.00588
EC			0.856	0.469	0.472	_-0.853
			0.00668	0.241	0.237	0.00710
pH				0.559	0.564	_-0.771
				0.150	0.145	0.0251
ESP					0.997	_-0.574
					0.0000000401	0.137
SAR						_-0.559
						0.150
Distance						

The Pair (s) of variables with positive correlation coefficient and P values below 0.050 tend to increase together. For the pair with negative correlation coefficient and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables

Chapter Four

Discussion

4.1 Soil properties of the study area before the industrial activities:-

Fig (3) is the Hunting Soil Survey Map (Soil Survey Division, Wad Medani, 1973) in which the site of Alsheikh Mustafa Alamin factory (SMA) is inserted . The area in light blue colour (soil series 1) was referred to as soil unit 131, Bageir (see Table 10, Chapter 4) in which various industries have been were established since 1974.

According to the Soil Survey Map (Hunting, op . cit) .the profile description and textural class of the soil is dark, grayish – brown, sandy- clay loam .The area with the green colour (Fig 3) lies beyond the study area and was designated soil series 2 The chemical & physical analyses of the soil unit 131, Bageir (Tables 10 &11) were carried out in 1973, before the beginning of the industrial activities . That is why it is used as a reference area in this study. Using data shown in table 10, three figures were drawn to show the following relationships:-

Fig (4) shows the relationship between electrical conductance (EC) and depth, where it is found to be very low at the two depths (30 & 60 cm).

Fig (5) shows the relationship between soluble sodium and depth, where the sodium content increases with depth.

Fig (6) shows the relationship between the exchangeable sodium percentage (ESP) and depth. Although the sodium content in the area is not high, but the ESP is very high in the two layers (30 & 60 cm)

exceeding 15%. This is due to the low concentration of calcium and magnesium (Table10).

Referring to (Table 10) the soil is strongly alkaline as showing by the high p H values & > 15 ESP values .Table 11 reveals that the soil is moderately drained since its sandy content is about 50%.

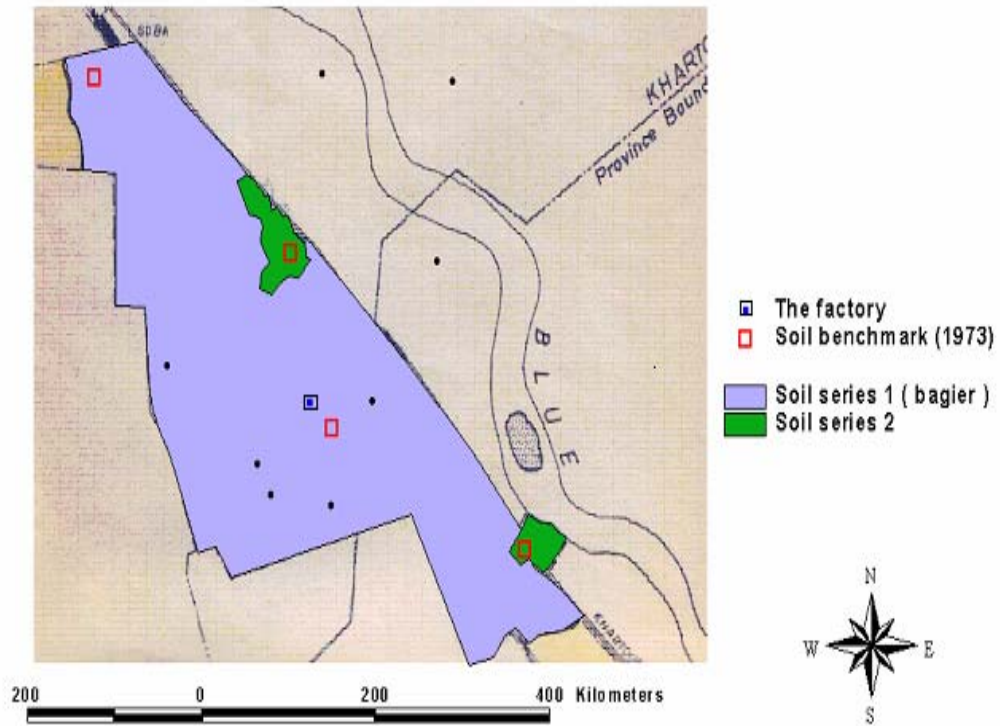


Table 10 : Chemical characteristics of samples from soil unit ,131 at Latitude 15° 20' , Longitude 32° 43' , Albageir area (Soil Survey Division , Wad Medani,1973).

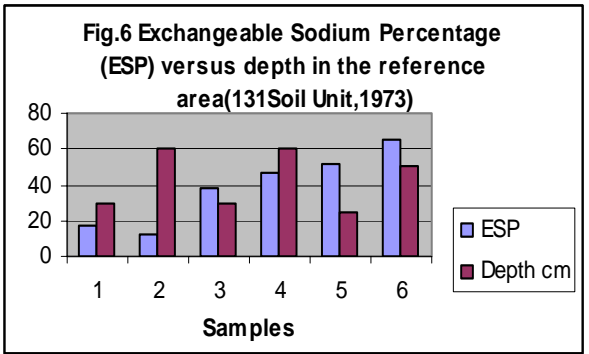
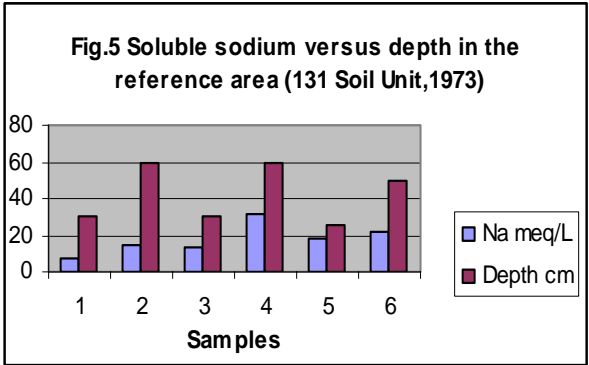
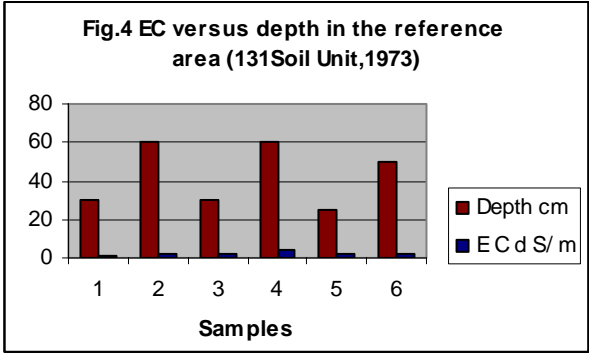
Map symbol & name	Sample No.	Depth in cm	PH of soil		E.C <u>mmho</u> cm	Soluble cations & anions meq/l				ESP	SAR
			paste	1:5		Na	Ca	Mg	CL		
131 Bageir	06029	0-30	8.6	9.8	1.68	13	1	0.2	3.6	37.8	19.4
	06030	30-60	8.5	9.8	4.00	31.4	13	2.4	11.1	47.1	32.7
131 Bageir	03012	0-30	8.7	9.8	1.46	7	0.6	0.2	2.8	17	10.4
	03013	30-60	8.8	9.7	1.62	14	1.2	0.4	7.4	12	15.6
131 Bageir	01001	0-25	8.9	7.2	1.56	18	0.8	0.2	6	51.2	23.8
	01002	25-50	8.7	4.4	2.23	22	1.2	0.2	5.6	65.4	26.2
131 Bageir	06022	5-20	9	8.8	1.36	14	1.3	0.2	3.4	36	15.6
	06023	20-55	8.6	9.5	2.7	21.8	2.3	0.4	5.5	67.5	32

ESP = Exchangeable Sodium Percentage.

SAR = Sodium Adsorption Ratio.

Table 11 : Mechanical analyses of fine soil (Soil Unit,131 Bageir,1973).

Map symbol&Name	Sample No.	Depth (cm)	Coarse sand%	Fine sand%	Silt%	Clay%
131 Bageir	06029	0-30	31	22	9	22
	06030	30-60	17	32	19	29
131 Bageir	03012	0-30	41	22	9	23
	03013	30-60	42	15	9	29
131 Bageir	01001	0-25	25	19	7	22
	01002	25-50	28	18	16	36
131 Bageir	06022	5-20	33	19	11	29
	06023	20-55	26	22	13	36



4 . 2 Effect of the industrial activities on groundwater & soil in the study area:-

4 . 2 .1 Groundwater:-

The results of water analyses will be reviewed and discussed in the light of the standards of the World Health Organization (WHO, 1982, Appendix 1) and the Sudanese Standard Metrological Organization (SSMO, 2002, Appendix 2).This is done in order to test the suitability of groundwater for drinking purposes.

The results of chemical analysis of groundwater from five wells in the study area are shown in Table 6, Chapter 3 . As mentioned earlier in Chapter 3 the pH values range from 7.2 in well No. 3 (Fig .9) to 7.8 in well No.1 (Fig . 7) and No. 4 (Fig.10).These values lie within the permissible range (6.5 -8.5) of the WHO (1982) and the SSMO (2002). It is classified as neutral water by the two standards.

The concentration of The Nitrates varies between 10.2 mg/L in the water from well No. 2 (Fig. 8) to 15.9 mg/L in well No. 5 (Fig.11). The sum of the Nitrates & Nitrites as indicated by the WHO Guide line should not exceed 10mg/L , but according to the SSMO (2002), these values lie below the maximum limit. According to the Sudanese National Standard, 1982, Appendix 3 there is no harmful effect on human health recorded even when the drinking water contains up to 200

mg/L Nitrates (level B). In his report (Driscoll,1986) stated that concentrations greater than 45mg/L are undesirable in domestic water supplies, especially for young infants where a concentration of 90 mg/L is considered harmful to them.

Ammonia is present in small concentrations ranging from 0.3 mg/L in water from well No. 4 (Fig.10) to 0.6 in well No. 2 (Fig 8), which means that the content of organic matter is very low.

The concentration of sodium varies between 12.5 mg/L in well No.5 (Fig.11) to 62.4 mg/L in well No. 3 (Fig. 9). These values are below the standard level of the WHO Guideline for drinking water, which is 150 mg/L.

Potassium values lie between 1.8 mg/L in well No. 5 (Fig.11) and 6.5 mg/L in well No. 4 (Fig.10).This is a very low concentration of the element according to the WHO standards(op.cit).

Chromium values vary between 0.04 mg/L in wells No. 3 (Fig. 9) & No. 4 (Fig. 10) and 0.06 mg/L in well No. 1 (Fig.7) .The values are within the standard limit of the WHO (op.cit).A slight increase in well No.1 may be due to its proximity to the tannery waste disposal site.

The chloride values vary between 14 mg/L in well No. 5 (Fig.11) 35.5 mg/L in wells No. 1 (Fig. 7) & No. 2 (Fig . 8). According to the WHO (1982) standard ,these values lie within the low range of concentrations of the anion.

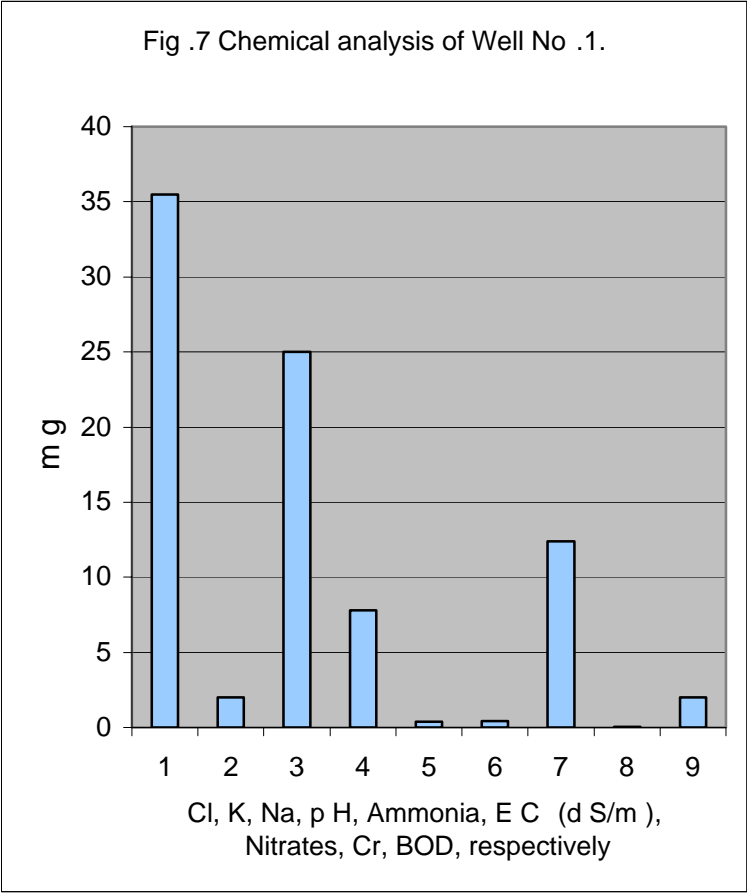


Fig . 8 Chemical analysis of Well No . 2 .

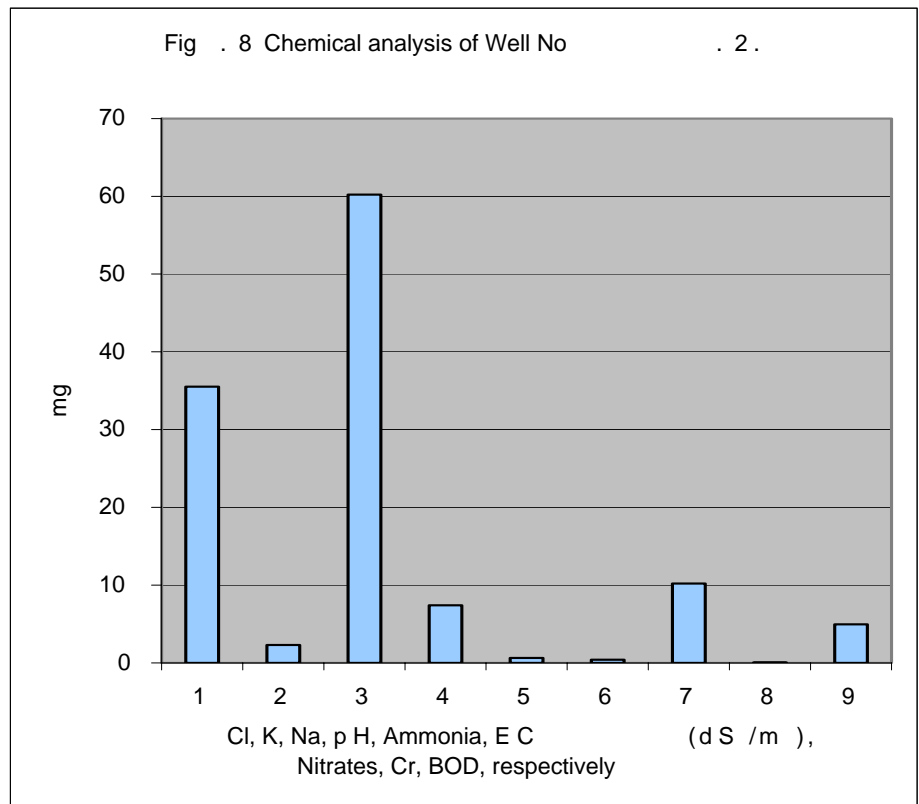


Fig . 9 Chemical analysis of Well No . 3 .

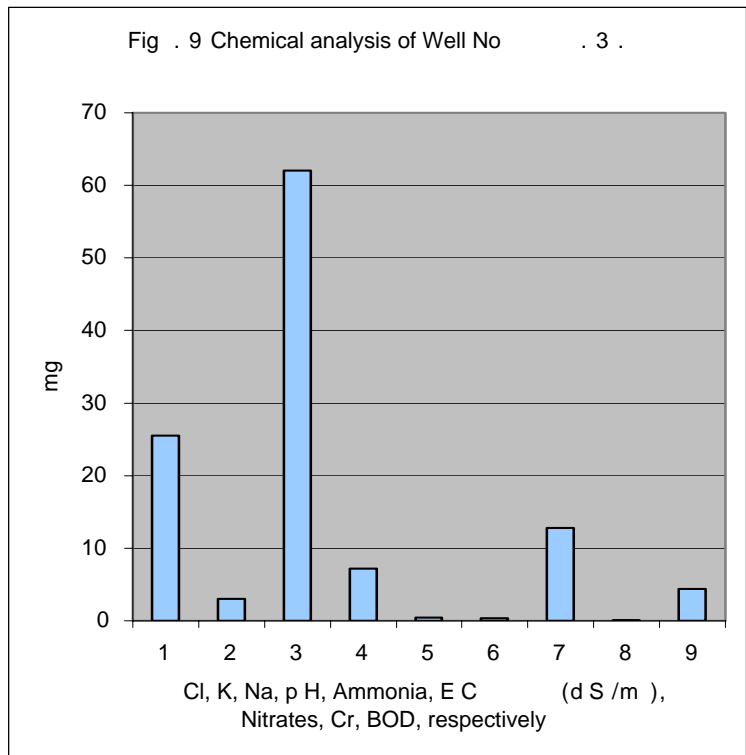


Fig . 10 Chemical analysis of Well No . 4 .

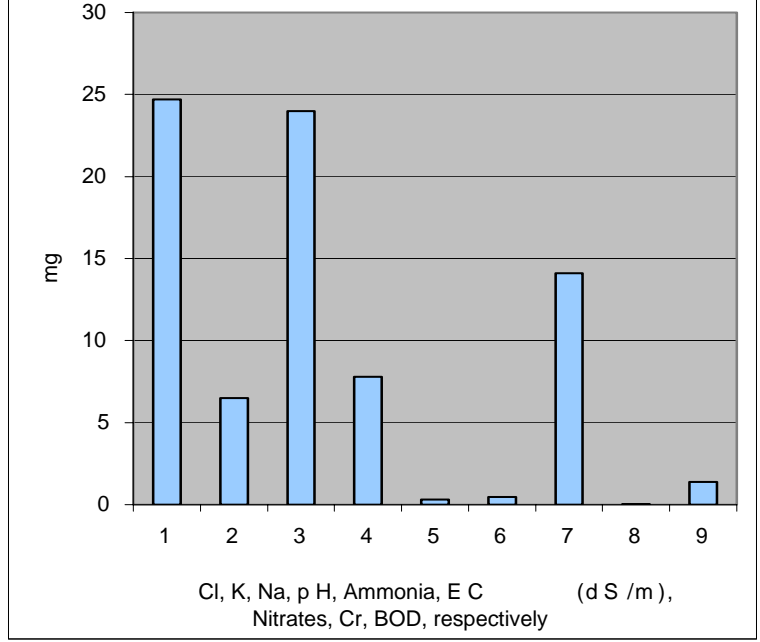
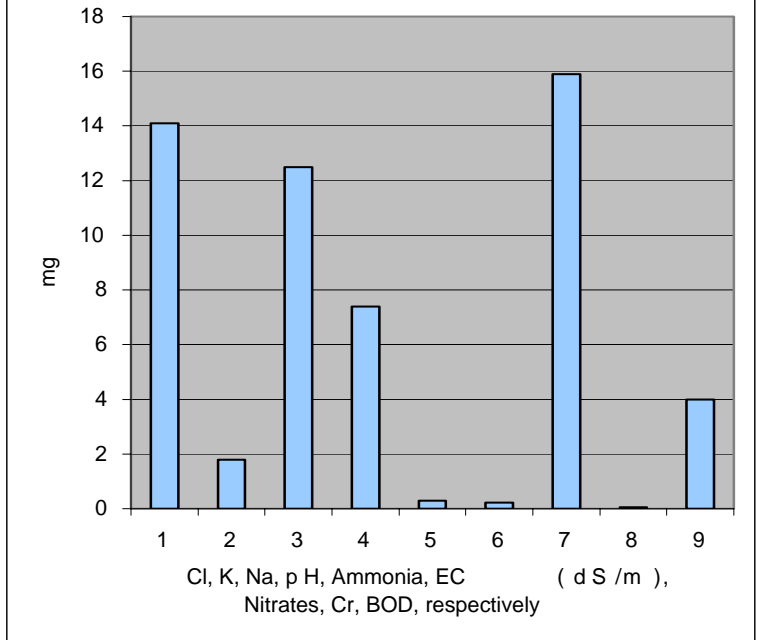


Fig . 11 Chemical analysis of Well No . 5 .



The Biochemical Oxygen Demand (BOD) values range from 1.4 mg/L in well No. 5 (Fig .11) to 5 mg/L in well No. 2 (Fig . 8) , thus reinforcing the very low concentration of organic matter already revealed from the ammonia determinations.

The EC values lie between 0.22 and 0.45 d S/m in the water from wells No.5 (Fig . 11) & No. 4 (Fig . 10), respectively , which indicates the very low concentration of soluble ions. This probably suggests that the wells in the study area tap deeper aquifer levels.

4 . 2 . 2 Soil :-

4 . 2 . 2 . 1 The pH :-

Table 12 : Results of the p H determinations of the eight soil samples (S1 – S8) analyzed from the four pits (A – D)

Depth (cm)	Pit No. & distance from pond			
	A (25m)	B (50m)	C(100m)	D(150m)
25	S1 : 10.3	S3 : 9.2	S5 : 9	S7 : 8.4
50	S2 : 10.2	S4 : 8.5	S6 : 8.3	S8 : 8.2

Table (12) shows the results of analyses for p H values in the soil samples taken at distances from the effluent pond and from different depths . The p H value varies from 10.3 in the soil sample no. S1 (Pit A) taken from a depth of 25 cm & a distance of 25 m away from the effluent pond to 8.4 in the soil sample No. S7 (Pit D) at a depth of 25 cm and a distance of 150 m away from the effluent pond. The

highest p H value (10.3) recorded by the soil sample no. S1 mentioned above can be explained by its nearness to the effluent pond which is rich in sodium ions resulting from soap industry. The lowest value which is given by the soil sample No. S7 can be explained by its distant location (150 m) from the effluent pond. Generally, the p H values decrease with increase in distance from the effluent pond as reflected by the results of the intermediate samples. Table (9), Chapter (3) shows the correlation coefficient between the different samples where the p H has a strong negative correlation with distance, having a correlation coefficient of -0.77 .

Also, the p H values were found to be higher in the upper soil layer of the analyzed pits (25 cm deep) than in the lower layer (50cm deep, Table 12) . This may be due to the relatively higher content of clay in the upper layer (Table 8) , where the sodium ions are most likely adsorbed by the clay particles . However, the variation in the p H values in the upper and lower layers is not high, as reflected by the weak negative correlation coefficient (-0.259 , Table 9) . Generally , the p H values in the study area reflect a medium to high alkalinity of the soil, resulting from the effluent of the soap industry .

4.2.2.2 The Electrical conductivity (EC) :-

Table 13: Results of the EC determinations (in d S/m) of the eight soil samples (S1 – S8) analyzed from the four pits (A – D)

Depth (cm)	Pit No. & distance from pond			
	A (25m)	B (50m)	C (100m)	D (150m)
25	S1 : 12.55	S3 :10.85	S5 : 11.85	S7 : 4.4
50	S2 : 13.34	S4 : 9.20	S6 :6.78	S8 : 6.21

The EC for each soil sample analyzed is more than 4 decisiemens per meter (d S/m). That means that the soil content of soluble salts of sodium ,calcium ,magnesium & potassium, chlorides and sulphates is high. The EC values were less than 4d S/m in the reference soil unit (131) Bageir, indicating a low content of soluble salts in the soil before the industrial activities. The increase in the salinity is likely to have resulted from the effluent of soap industry which started in 1982.

Referring to Table (13) and Fig. (12) the highest value is 12.55 d S/m is given by the soil sample No . S1 (Pit A) at a depth of 25 cm and at a distance of 25 m away from the effluent pond. On the other hand the lowest EC value 4.4 d S/m is found in the soil sample No.S7 (Pit D) at the same depth but at a distance of 150

m away from the effluent pond . Hence , the EC values decrease with increase in distance away from the effluent pond, thus reinforcing the same conclusion drawn from the p H values against distance. Table (9), Chapter (3) shows that the correlation coefficient between the EC & distance is strong negative correlation (-0.853). However, sample No. S5, Pit No. C gave an EC value of 11.85 d S/m which is not consistent with the general decrease in EC values with distance from the pond. This could be explained by the interference from other adjacent industries due to random disposal of wastewater.

There is a slight difference in the EC values in the same (Pit A) in the soil sample No. S1 at a depth of 25 cm and the soil sample No. S2 at a depth of 50 cm (Table 13 & Figure 12).This is also true concerning the soil sample No. S3 (Pit.B) at a distance of 50 m away from the effluent pond and a depth of 25 cm and the soil sample No. S4 (from the same pit) at a depth of 50 cm. This equal distribution of soluble salts in the two layers of (Pit A & Pit B) may be due to their proximity to the effluent pond, where the concentration of soluble salts

is high . However, in the soil sample No. S5 (Pit C) at a distance of 100 m away from the effluent pond and at a depth of 25 cm, the EC value is 11.9 d S /m , while it is 6.8 d S /m in the soil sample no. S6

from the same pit at a depth of 50 cm. That means that the upper layer contains more soluble salts than the lower layer. This can be explained by the relatively low sand content in the upper layer (Table 8) which rendered it less permeable in order to allow the soluble salts to pass easily to the lower layer. In the soil sample No. S7 (Pit D) at a distance of 150 m from the effluent pond, the EC value is 4.4 d S/m at a depth of 25 cm, while it is 6.2 d S/m in the soil sample No. S8 from the same pit taken from a depth of 50 cm. That could be attributed to the higher sand content in the upper soil sample No. S7 than that in the lower soil sample No. S8 (Table 13). Hence, the upper soil sample No. S7 has a higher permeability that allows the soluble salts to pass through easily. Referring to Table (9), it is clear that the EC has a weak negative correlation with depth, having a correlation coefficient of (-0.167). On the other hand, the EC has a strong positive correlation with the pH having a correlation coefficient of (0.856).

4.2.2.3 The Sodium :-

Table 14: Results of the sodium determinations (in meq/L) of the eight soil samples (S1 – S8) analyzed from the four pits (A – D)

Depth (cm)	Pit No. & distance from pond			
	A (25 m)	B (50 m)	C (100 m)	D (150 m)
25	S1 : 72.8	S3 : 71.7	S5 : 65.2	S7 : 34.7
50	S2 : 102.1	S4 : 63	S6 : 41.3	S8 : 39.1

Table (14) & Figure (13) show the results of analyses of the sodium content in the soil samples taken at distances from the effluent pond & from different depths .The sodium content varies from 72.8 meq/L in the soil sample No. S1 (Pit A) at a depth of 25 cm and a distance 25 m away from the effluent pond to 34.7 meq/L in the soil sample No.S7(Pit D) at a depth of 25 cm and distance 150 m away from the effluent pond .The highest value was recorded by the soil sample No. S1 (Pit A) which is the nearest sample to the effluent pond .The lowest value given by the soil sample No.S7 (Pit D) which is the farthest soil sample from the pond. Table (9) shows the correlation coefficient of sodium content with distance (-0.865) which it is a strong negative correlation , indicating that the sodium content decreases with increase in distance away from the effluent pond.

Considering the vertical variation of the sodium content in the analyzed pits (Table 14), it is clear that there is no general trend of increase or decrease of sodium with depth. For example, in Pit No. A & D the higher sodium content is found in the lower part (50 cm deep) of the pits; whereas, in pit no. B & C the higher sodium content is found at the upper part (25 cm deep) of the pits. This is probably because the clay content in the two layers is not homogeneous, a fact that leads to the adsorption of sodium ions by the clay particles. This is reflected by the higher content of clay in the upper horizons of Pits No. B & C. Table (9) shows that the correlation coefficient between sodium and

depth is (0.00655) i.e. almost zero, which means that the relationship is not linear.

In the reference soil (unit 131, Bageir) , sodium values vary between 7 and 31.4 meq/L (Table10) indicating quite low values of the element before industrialization .The increase in sodium concentration can be attributed to the effect of the effluent of the soap industry .

4 . 2 . 2 . 4 The Chlorides :-

Table 15: Results of the chloride determinations (in meq/L) of the eight soil samples (S1 – S8) analyzed from the four pits (A – D)

Depth (cm)	Pit No. & distance from pond			
	A (25 m)	B (50 m)	C (100 m)	D (150 m)
25	S1 : 59	S3 : 51	S5 : 45	S7 : 27
50	S2 : 135	S4 : 88	S6 : 35	S8 : 41

Table (15) shows the results of analyses of the chloride content in the soil samples taken at distances from the effluent pond & from different depths..The highest value is 59 meq / L which was recorded by the soil sample No. S1 (Pit A) at a distance 25 m from the effluent pond and at a depth of 25 cm. The lowest value is 27 meq / L which was recorded by the soil sample No. S7 (Pit D) at the same depth but

150 m from the effluent pond . Hence the chloride values decrease with distance from the effluent pond .

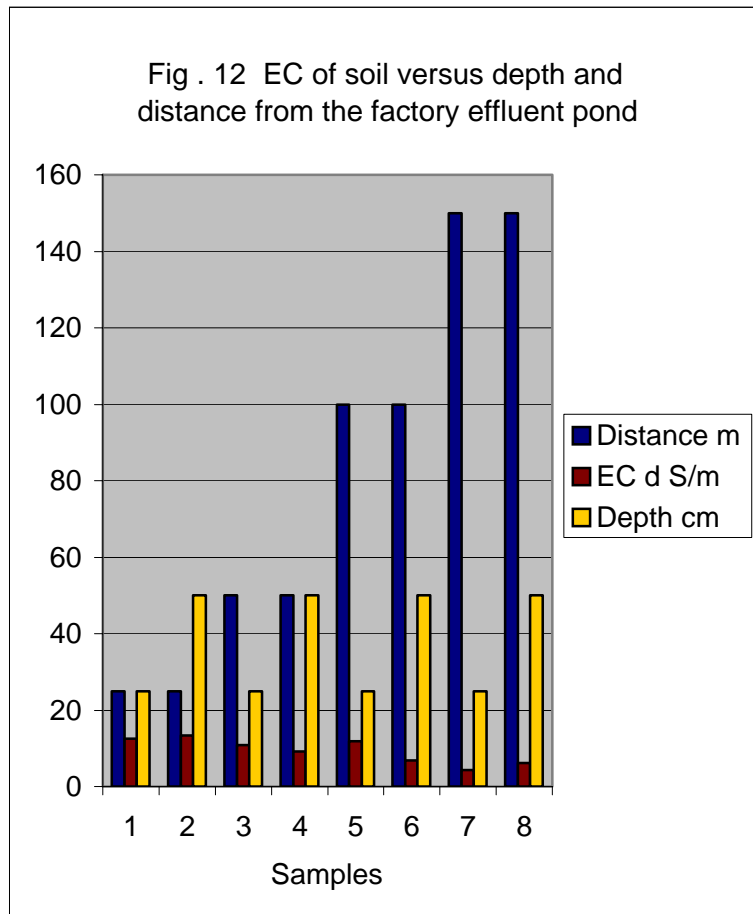


Fig . 13 Soluble sodium content in soil versus depth and distance from the factory effluent pond

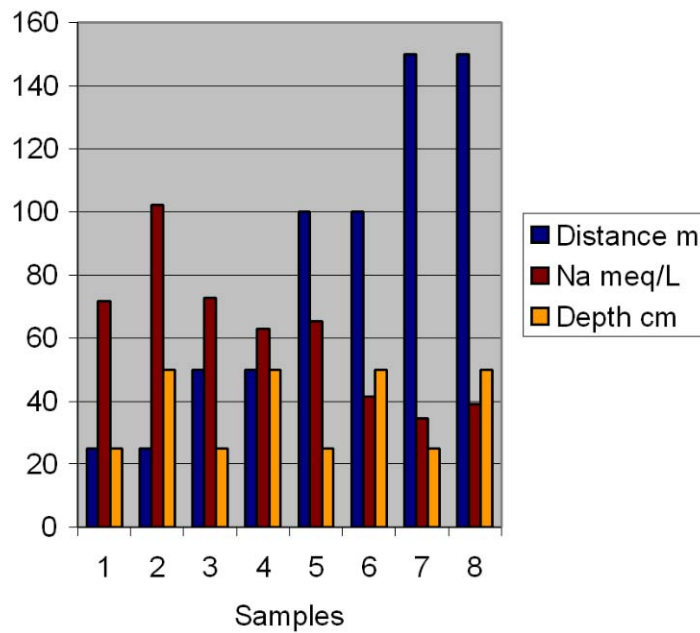
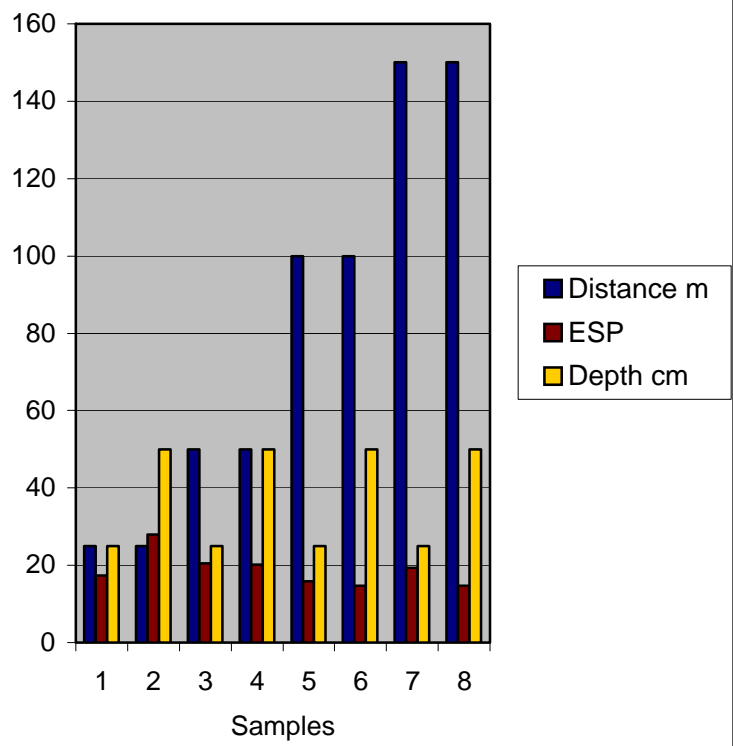


Fig .14 Exchangeable Sodium Percentage (ESP) in soil versus depth and distance from the factory effluent pond



Generally, the chloride values were found to be lower in the upper soil layer (25 cm deep) than in the lower layer (50 cm deep). The upper layer being quite leachable, explains the higher values of the chloride at the lower levels. The high concentration of the chlorides in general is probably due to its very high content in the effluent pond, since the soil sample no. S0, table 7 (from the western periphery of the pond) contains 417 meq / L chloride. The chloride status was assessed at a depth of 25 cm, because this is the layer from which plant roots obtain the nutrients in the form of soluble salts. Accumulating excessive levels of chloride in the soil can be toxic, resulting in chloride sensitive crops (www.science.org)

4.3 Type of soil under investigation :-

Soils are considered to be the most important resource in the long run in any country. The inventory and use of that resource will determine to a large extent the survival and progress of the nation (Loehr,1977).

Generally, soils can be classified according to salinity and alkalinity (Thorne & Peterson, 1971).

a- Saline Soils :-

This term is coined for soils containing sufficient soluble salts to interfere with the growth of most crop plants. The point at which the growth of common plants is hampered by salts is near the conductivity of the saturation extract of 4 millimhos/cm. Soils having this salt content

or higher and exchangeable Sodium percentage less than 15 are defined as saline soils. The pH is usually 8.5. In these soils sodium usually comprises less than half of the soluble cations, so that it is not appreciably adsorbed. The principal anions are the chloride, the sulphate, small amounts of bicarbonate and occasionally some nitrate. Measurable quantities of soluble carbonate are usually absent (Thorne & Peterson, op.cit).

b- Sline-Alkali Soils :-

They are defined as soils which contain sufficient exchangeable Sodium to interfere with the growth of most crop plants and which contain appreciable quantities of soluble salts. The conductivity of the saturation extract is greater than 4 milliohms/cm and the exchangeable-Sodium percentage is greater than 15. Under conditions of excess salt the pH values of these soils are seldom higher than 8.5 and the soil colloids remain flocculated. If these soils are leached so that the high sodium concentration in the soil solution is lowered, some of the exchangeable Sodium hydrolyzes to form Sodium hydroxide. The Sodium hydroxide so formed may react with carbon dioxide. In either case, the soil becomes highly alkaline with pH above 8.5. The colloids become dispersed and the soil assumes a very light structure with low permeability (Thorne & Peterson, op. cit).

c- Non-Saline-Alkali Soils:-

This group includes soils containing sufficient exchangeable

Sodium to interfere with growth of most crop plants and not containing appreciable quantities of soluble salts .The Exchangeable Sodium Percentage (ESP) is greater than 15 and the conductivity of the saturation extract is less than 4 millimhos/cm.The pH values generally range between 8.5 and 10.

A saline - Alkali Soil when leached without a source of calcium to replace sodium leads to the formation of non-saline alkali soils. The removal of the soluble salts from the high sodium saturated soil colloids allows them to be deflocculated and run together with the formation of a tight structure unfavorable for irrigation or drainage. The soil solution of the non-saline soil is relatively low in soluble salts and the composition of the solution is quite different from that of saline and normal soils. Some of the normal carbonate anions usually occur in addition to the chloride, sulphate, bicarbonate and other anions. Usually calcium and magnesium are precipitated by the carbonate anions and so they form only a small portion of the total soluble cations. Sodium is the dominant cation present except in a few soils where potassium may occur in large quantities (Thorne & Peterson, op. cit).

Reviewing the chemical properties of Albageir soil under investigation it is clear that it belongs to the Saline – Alkali category of soils i.e. it is highly sodic alkaline soil characterized by a high content

of soluble salts and low permeability . That means a great loss of a valuable resource due to the improper disposal of waste from the factories .

Chapter Five

Conclusions and Recommendations

5.1 Conclusions :-

The soap industry at SMA factory at Albageir area is chosen in order to investigate the deleterious impact of the industry on the environment. Groundwater samples taken from wells were analyzed for, Biochemical Oxygen Demand (BOD), chromium, nitrates, EC, ammonia, pH, sodium, potassium & chlorides. Soil samples were analyzed for p H, EC, sodium & chlorides.

The analyses of the groundwater samples showed that they are generally clear and suitable for drinking . The wells are not , so far , affected by any chemical pollution from the effluent pond .This is because the wells tap water from the deeper aquifer as indicated by the water levels (Table 6).

The study revealed the contamination of soil in a halo extending from 150 m to the west of the effluent pond of the soap factory. For example, the sodium content reached 72.8 meq/L in the Pit closest to the effluent pond though it reaches 34.7 meq/L towards the edge of the dispersion halo, likewise high values of EC were found in the Pit closer to the effluent pond, while low values were found in the Pit farther from it. The P H and chlorides followed suite. It is concluded that this soil is unfavorable for agricultural use.

The reference area (Soil unit 131, Bagier) was classified as Alkaline soil (Soil Survey Division, 1973) before the establishment of the industrial activities. The study area can be classified as Saline-alkali soil according to the classification mentioned in Chapter 4. As the study area is drained by runoff to almost more than 300m in diameter from the effluent pond at the rainy season, horizontal dispersion could cause the ions to travel to long distances. No plant is seen within the analyzed area which may indicate that a process of soil degradation is taking place and one day it could reach a magnitude that can not be rectified. Most crops do not grow well in soils that contain salts. One reason is that salts cause reduction in the rate and amount of water that the plant roots can take up from the soil. Also some salts are toxic to plants when present in high concentrations in the soil. A sodic soil is one in which there is a high exchangeable sodium percentage (ESP), which means a relatively large number of sodium ions on the clay surface. High levels of sodium make the clay particles less sticky, so that they do not adhere or hold together so well. In the rainy season the runoff combined with the sodicity cause the clay particles to disperse. The disruption of soil texture by sodium precipitation, together with clay dispersion, generally reduce the soil permeability, since the larger pores become blocked. When the pores become blocked, incoming water has nowhere to go to.

The net result is a water logged soil surface .When excess water evaporates, the soil sets hard and becomes crusty and consequently the drainage and aeration are impeded. Sodic soils are known to reduce permeability and plants find them hard to penetrate, and consequently plant growth is adversely affected. Fewer plants mean fewer roots to bind the soil, thus making it more vulnerable to water and wind erosion.

Soil salinity tends to increase with the increase in clay content (Aoad,1974). In this study (Table 8) the clay content is less than sand , which indicates that the salinity could increase with the increase of the industrial effluent and this will affect the adjacent farmland and lead in the near future to a depressive effect on productivity .

the writer did not endeavour to correlate these results with similar investigations carried out in the industrial areas in the Three Towns .This is because this study concentrates on one industry ,viz. the soap industry in Al bageir area, whereas the studies carried out in the industrial areas mentioned above concentrate on the overall pollution of the different industries in each area. That is why direct correlations would be rather meaningless.

5 . 2 Recommendations :-

- Proper disposal of liquid waste after treatment .Most of the factories do not have treatment plants.

- A strict regulation should be formulated by the authorities to prevent the pollution of the area by all kinds of waste.

- In the industrial area , sanitary facilities for waste disposal are still lacking. This is a very serious problem that needs solving by constructing adequate sanitary facilities for waste disposal.

- Monitoring of ground water quality is also recommended.

- Special soil reclamation measures should be adopted in the affected areas.

- New water wells should always be drilled down to the deeper aquifer followed by cement grouting above the aquifer .

- Due to financial constraints the soil & water analyses made are not enough to delineate the real extent of the soil degradation that resulted from soap industry at Al bageir area . More sampling & analyses are required in order to achieve that goal and launch a soil reclamation programme for the recovery of the soil potential as a valuable resource. The sampling should include plants, vegetables &even milk, since chromium is a poisonous heavy metal is used in the adjacent tannery.

- Future studies should investigate the effect of these industries (soap & oil) in the area so that attention should be drawn to the importance of treatment plants. This is important in order not to pollute the adjacent Blue & White Nile waters and the aquatic life in them, especially fish.

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Appendix 1

Some Examples of Drinking Water Action Level. (WHO, 1982)

Constituent	Action Level mg/L
Aluminum	0.2
Antimony	0.005
Arsenic	0.05
Barium	0.7
Boron	0.3
Cadmium	0.005
Chromium	0.05
Copper	1
Cyanide	0.1
Chloride	250
Fluoride	1.5
Hardness as CaCO ₃	500
Iron	0.3
Lead	0.05
Manganese	0.1
Mercury	0.001
Nickel	0.1
Nitrate and Nitrite Nitrogen	10.1
Selenium	0.01
Sulphate	400
Sodium	200
Zinc	5.0
Chlorophenols	0.1ug/L
Chloroform	30ug/L
pH	6.5-8.5

Appendix 2

**Maximum Permissible Limit of Different Parameters That
Might Affect consumer acceptance for drinking water**
(Sudanese Standard Metrological Organization, 2002)

Parameter	Maximum Permissible Limit in mg/L
Colour	15 True color unit
Taste & Odor	Acceptable
Temperature	Acceptable
Turbidity	5Nephelometric Turbidity Unit
pH	6.5-8.5
Aluminum	0.2 mg/L
Ammonia	1.5mg/L
Hydrogen Sulphide	0.05mg/L
Iron total	0.3mg/L
Sodium	200mg/L
Sulphate	250mg/L
Total dissolved solids	1000mg/L
Zinc	3mg/L
Chromium(Total)	0.04mg/L
Copper	1.5mg/L
Cyanide	0.05mg/L
Fluoride	1.5mg/L
Lead	0.007mg/L
Manganese	0.5mg/L
Mercury total	0.0007mg/L
Molybdenum	0.05mg/L
Nickel	0.014mg/L
Nitrogen asNO ₃	50mg/L
Nitrogen asNO ₂	2mg/L
Chloride	250mg/L
Antimony	0.004
Arsenic	0.007
Barium	0.5
Boron	0.2
Cadmium	0.003

Appendix 3

The Sudanese National Standard for drinking water (1982

)

Substance	Level A mg/L	Level B mg/L
Taste and odour	Not offensive	-
Colour	15 True colour unit	-
Turbidity	5 NTU	-
P H value	6.5-8.5	-
Aluminum	0.2	-
Chloride	250	-
Copper	1.0	-
Hardness as Ca CO ₃	500	-
Iron	0.3	-
Manganese	0.1	-
Sodium	200	-
Sulphate	400	500
Total dissolved solids	1000	5000
Zinc	5.0	-
Arsenic	0.05	0.05
Cadmium	0.005	0.005
Chromium	0.05	0.05
Cyanide	0.1	0.1
Fluoride	1.5	10
Lead	0.05	0.05
Mercury	0.001	0.001
Nitrate + Nitrite	45	200
Selenium	0.01	0.01

Appendix 4

Description of the analytical methods used

A - BOD value was calculated according to the following equation:

$$\text{BOD mg / L} = \frac{D_2 - D_1}{V}$$

Where D_2 = Immediate dissolved oxygen

D_1 = dissolved oxygen after 5 days

V = Volume of BOD bottle in (ml)

D_2 & D_1 were calculated by Winkler method:-

Reagents :-

1 ml of Manganous Sulphate

1 ml of potassium Iodide

1 ml of sulphuric acid

Sodium thiosulphate

starch indicator

Method :

For 100ml water sample 1ml of Manganous Sulphate, 1 ml of potassium Iodide & 1 ml of sulphuric acid was added. Then Titrated against Sodium thiosulphate using starch as an indicator.

Calculations:-

$$\text{Oxygen mg/L} = \frac{N * T * 1000 * 8}{V}$$

N = Normality of titrant

T = volume of titrant

V = Volume of sample

B - Chloride determinations for both groundwater and soil samples

:-

Reagents:

Silver nitrate & Potassium chromate indicator

i) Groundwater sample:-

Pipette 25 ml of water sample in a conical flask, add few drops of potassium chromate indicator and titrate with silver nitrate.

Calculation :

$$\text{Chloride content (mg/L)} = \frac{(A - B) * N * 35.450 * 1000}{V}$$

Where A = Titrant (ml).

B = Blank (ml).

N = Normality of Silver Nitrate.

V = Volume of sample(ml).

ii) Soil samples:-

The soil analyses was carried out from the soil extract which was prepared by adding 200ml distilled water to 50 grams of soil then left for 24 hours and filtered to obtain the soil extract.

Chloride Test for soil samples:-

Reagents:

Silver nitrate

Potassium chromate indicator

Method:

Pipette 5ml of soil extract into a conical flask, dilute to 25ml with distilled water, add two drops of potassium chromate then titrate with silver nitrate.

Calculation:

$$\text{Chloride content (meq / L)} = V * N * 1000 / V1$$

Where V = Volume of silver nitrate (ml) .

N = Normality of silver nitrate.

V1 = Volume of sample (ml)

C - Determination of sodium & potassium cations :-

Sodium and potassium cations for both water and soil samples were measured by Atomic Absorption Spectrophotometer

D -Determination of calcium and magnesium cations in the soil samples:-

Reagents :
Ethylenediaminetetra - acetic acid (EDTA).
Ammonium chloride as a buffer.
Eriochrome Black T (E B T) indicator.

Method:

0.5 ml of the soil extract were pipetted in a conical flask and diluted to 25 ml with distilled water, 1ml of ammonium chloride and two drops of the indicator were added then titrated with (EDTA).

Calculation :

$$\text{Ca} + \text{Mg meq} / \text{L} = \text{N} * \text{V} * \text{Dilution factor} / \text{Volume of sample}$$

N = Normality of EDTA

V = Volume of EDTA.

E- Determination of the p H Values:-

i) The P H values for groundwater samples were measured by a p H meter (HACH Co150).

ii) The p H values for soil samples were measured by direct reading from a p H meter (electro. Mag M822).

F -Electrical Conductivity:-

i)Electrical Conductivity for groundwater samples was measured by a conductivity meter (HACH EC 10).

ii)Electrical Conductivity for soil samples was measured by a conductivity meter (Jenway 4510).

G-Determination of Sand & Silt in the soil samples:-

40 gm were taken from each sample and 200 ml of water were added. After shaking for 8 hours the samples were wet sieved with a (0.045 *0.063 mm) sieve. The remaining sand was weighed and the percentage of sand and silt was calculated.

The equations used for the soil and groundwater determinations are quoted from Page, Miller and Keeney (1982), American Public Health Association, American Water Works, Water Environment Federation (1998)respectively.