Assessment of Industrial Liquid Waste Management in Omdurman Industrial Area

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Dedication

Presented To: My beloved parents,

Brothers, sisters, friends

And all member of my family.

Table of Contents

Abstract

This study was conducted mainly to investigate the effects of industrial liquid waste on the environment in the Omdurman area. Various types of industries are found around Omdurman. According to the ISC the major industries are divided into eight major sub-sectors, each sub-sector is divided into types of industries. Special consideration was given to the liquid waste because of its effects.

In addition to the available data, personal observation supported by photographs, laboratory analyses were carried on the industrial effluents. The investigated parameters in the analysis were; BOD, COD, O & G, Cr, TDS, TSS, pH, temp & conductivity. Interviews were conducted with waste handling workers in the industries, in order to assess the effects of industrial pollution.

The results obtained showed that pollutants produced by all the factories were found to exceed the accepted levels of the industrial pollution control. The effluents disposed of in the sites allotted by municipal authorities have adverse effects on the surrounding environment and public health and amenities.

Accordingly the study recommends that the wastewater must be pretreated before being disposed of in site allotted by municipal authorities. Develop an appropriate system for industrial waste proper management. The study established the need to construct a sewage system in the area in order to minimize the pollutants from effluents.

الخلاصة

أجريت هذه الدراسة لتقييم أثر الفضلات الصناعية السائلة على البيئة في منطقة أم درمان وقد وجدت أنواع مختلفة من الصناعات في منطقة الدراسة .

وفقاً للتصنيف الدولي القياسي قسمت هذه الصناعات إلى ثمانية قطاعات فرعية أساسية متضمنة كل أنواع الصناعة. وقد أعطيت الفضلات السائلة أهمية نسبة لتأثيرها على البيئة .

تم التدعيم بالملاحظات الشخصية والصور الفوتوغرافية بالإضافة إلى البيانات الموجودة . كما اجري التحليل المعملي على الفضلات الصناعية السائلة . وقد حللت عوامل الأكسجين الكيموحيوي الممتصة والأكسجين الكيميائي الممتص والزيوت والشحوم الموجودة بالفضلات السائلة . كما وانه تم استكشاف الرقم الهايدروجيني ودرجة الحرارة والموصلية الكهربائية مع كمية المواد الصلبة والذائبة بالإضافة لقياس تركيز الكروم في المدبغة .

وقد أجريت مقابلات مع العاملين الذين يقومون بالتخلص من الفضلات السائلة لتقييم اثر التلوث الصناعي .

أظهرت النتائج أن حجم الملوثات الناتجة من جميع المصانع المدروسة تفوق الحد المسموح به للتخلص من الفضلات السائلة المحددة بواسطة القوانين والأوامر المحلية بالإضافة للموجهات العالمية وان تفريغ الفضلات الصناعية السائلة في المناطق المخصصة من قبل السلطات المحلية لها آثار ضارة على البيئة المحيطة والصحة العامة والناحية الجمالية .

وفقا لهذه الدراسة نوصي بضرورة معالجة أولية للفضلات السائلة قبل تفريغها في المناطق المخصصة .

إدخال نظام ملائم لإدارة رشيدة للفضلات الصناعية ، ضرورة إنشاء شبكة صرف صحي بمنطقة أم درمان لتقليل الملوثات في الفضلات الصناعية .

List of Tables

List of Figures

List of Plates

Abbreviations

BOD Biological Oxygen Demand

COD Chemical Oxygen Demand

O&G Oil and Grease

T.S Total Solids

D.S Dissolved Solids

S.S Suspended Solids

Q* Flow Rate

pH Hydrogen ions Concentration

ISC International Standard Code

Chapter One

1

Introduction

Chapter One

Introduction

1.1 General:

Environment is a physical and biotic habitat, which surround us, which we can see, hear, touch, smell and taste.

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 gets changed. Such activities include industrialization, 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 makes our life miserable (S. M., 1994).

Urbanization and industrial growth; complicate the problem because:

1. Natural resources were considered as free goods but population growth put a strain on this resources.
2. Environment is a sink where all the waste produced by man is assimilated. And it is impossible to dispose off waste materials out side the worlds (S. P., 1991).

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 wastes will help to protect the local and global environment

1.2 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 (Odum, 1971).

Industrial processes produce liquid, solid and gaseous wastes which can have negative effects on the environment and people; acid rain is an example it results from emissions of sulfur dioxides and nitrogen oxides from chimney and exhaust pipe. These waste are generated either during processing, or at the end of the production process (Nebel & Wright, 1999).

At a closer range these atmospheric pollutants can also increase respiratory diseases. Liquid wastes when disposed in water bodies without treatment is greatly affected the aquatic organism (Boon, 1990).

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 old refrigeration equipment, and the green house gases carbon dioxide and methane has been estimated to make a contribution seven to ten times greater than the same volume of carbon dioxide to the green house effect.

Rio conference objectives for waste management, as stated in the 1992 Earth summit Agenda 21

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

Local authorities should under take 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, unmanaged, pollute water courses and sewerage systems.

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 (WHO report).

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 (Elhaj, 1984).

So certain problem can arise such as pollution (heat transfer and radiation), carbon dioxide buildup and green house effect, and acid rain.

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 locally and can readily control; 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 a 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 emission 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.

1.3 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 him self, his household, those in his employment and those with whom he has a direct trading (Dix, 1981), 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 amount in the form of sewage waste, accidental discharge or as by-product of a manufacturing process or other human activity (Shakkak, 1984).

1.3.1 Water pollution:

Is defined by Dix (1981) as a natural change in the quality of water, which rendered it unusable or dangerous with regards to food, human, animal health, industry, agriculture, fishing or leisure pursuits. Also water pollution is defined by WHO in terms of

Its nature :

- Physical: temperature, suspended matter, color, etc.
- Microbiological: microorganisms such as bacteria, viruses, and protozoa.
- Chemical: mineral pollution (salts, heavy metals) or organic pollution pesticides, hydrocarbons, solvent)

It's Origin:

Urban: Community wastewater, rainwater, refuses tips.

Industrial: liquid and solid wastes 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)

Its distribution in time:

Permanent: infiltration from leaching of waste discharges.

Accidental: broken pipes, overturned tanks.

Seasonal: plant protection products, highway deicing products.

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:

Caused by the untreated oil spills from industry and power generation unit to the sea, may result in mortality to birds and contamination of shore lines, resulting in sever 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 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.

1.4 Industry in Sudan:

Industry in the Sudan started by the turn of this 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 and at El Girba in 1963. Then a tannery in Khartoum was established; followed by five dispersed food-processing plants.

Before World War II, the British governors' 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. 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 industry 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 that time from 1% in 1955/56 to 9.4% in 1970/71, and employment jumped from 900 to 4000 during the same period (Boon, 1990).

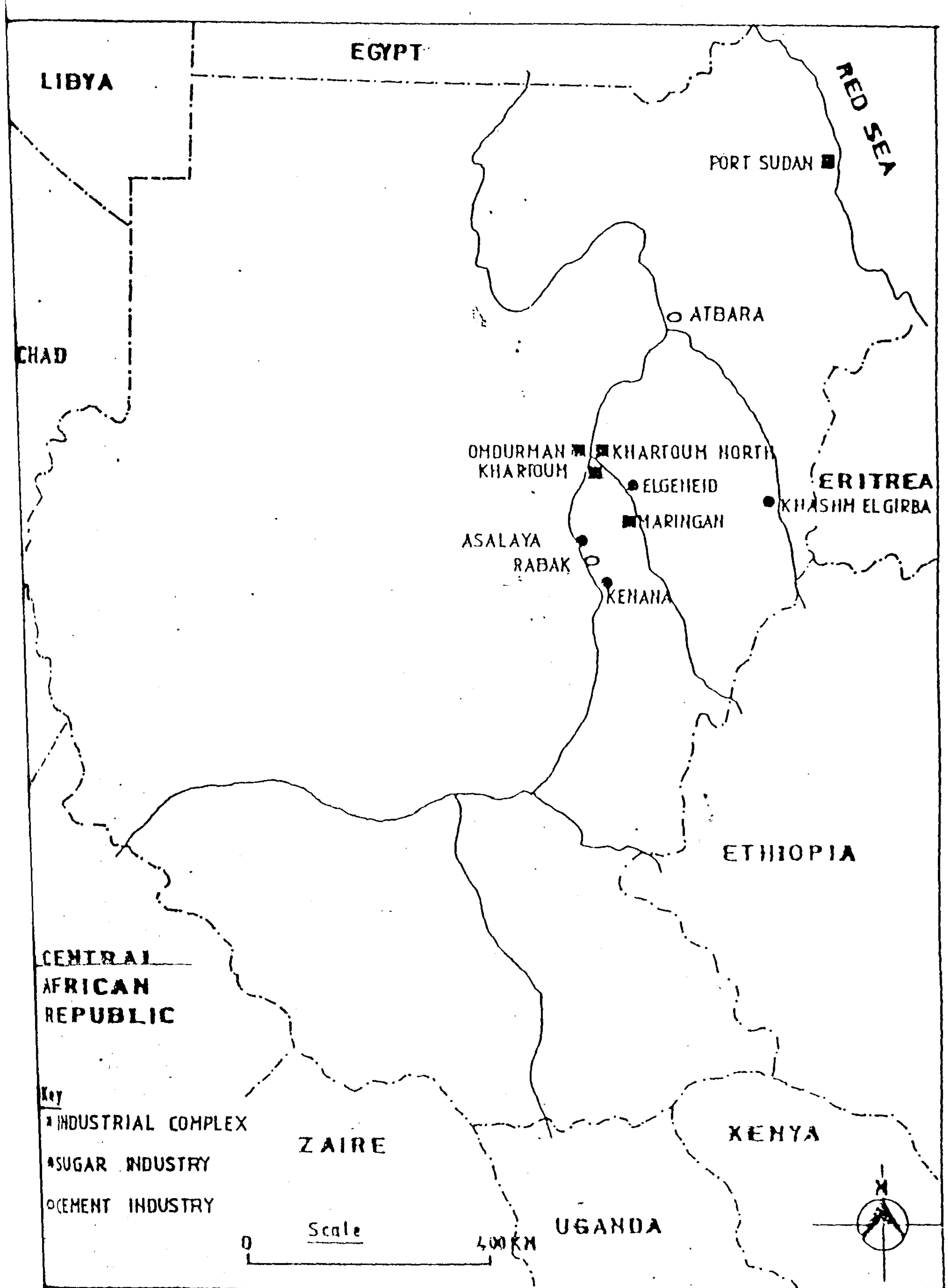
In 1960, the contribution of the industrial sector increased to 7.6%, and in 1973 increased to 15%. However, it fell to 8% in 1981 and went further down to 5% in 1985.

Industry plays a relatively small role in the economy of the Sudan and an accounts for less than twelve percent of GDP, ten percent of employment and less than one percent of exports. Manufacturing employment about 200,000 people.

The sector suffers from infrastructure bottlenecks and shortages of trained manpower, raw materials and the foreign exchange needed for importing essential intermediate inputs (UNDP report, 1994).

This situation agreed with the fact that says industrial development is given a high priority in most developing nations because such development creates employment and generates revenue that is badly needed (Boon, 1990).

Most of the industries in the Sudan are found in urban areas except industries that are attracted to their source of raw materials; Khartoum, Khartoum North, Omdurman, Port Sudan, Maringan & Gadid El Thawra industrial areas are example 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 (Fig. 1).



EGYPT
LIBYA
RED SEA
PORT SUDAN
ATBARA
CHAD
OMDURMAN
KHARTOUM NORTH
KHARTOUM
ELGENEID
ERITREA
KHASHM ELGIRBA
MARINGAN
ASALAYA
RABAK
KENANA
ETHIOPIA
CENTRAL AFRICAN REPUBLIC
Key
INDUSTRIAL COMPLEX
SUGAR INDUSTRY
CEMENT INDUSTRY
ZAIRE
KENYA
UGANDA
Scale
0
400 KM
N

Structure, Status and Location:

According to the UNIDO industrial survey, there were 6759 manufacturing establishments in the Sudan in 1981/82. 6412 of the establishments were classified as small, employing less than 25 workers. The larger establishments comprised 131 units employing 25-50 workers, 79 units employing 51-100 workers and 137 units employing more than 100 workers. The total manufacturing employment was estimated to be 144 500 persons. Most of the manufacturing sector was privately owned. Already in the early 1980's private sector accounted for 84% of manufacturing establishments and 79% of gross output. After the recent privatization program, the *share of the* private sector has become even- more dominant (UNDP report, 1994).

Table (1): Economically active population in manufacturing

(10 years and over)

Active population	Manufacturing	Total employment	Manufacturing Per Total %
Managers, Professionals	5050	199670	2.5 %
Technicians, Assoc. Professionals	7220	507970	1.4%
Clerks, Sale workers	20990	321720	6.5%
Craft workers	217560	485600	44.8%
Skilled Agricultural workers	3610	3093240	0.1%
Plant and Machine operators	34110	230800	14.8%
Elementary Occupations	33570	843870	4.0%
Others	1120	201370	0.6%
Total	**323340**	**6884200**	**5.5%**

Source: Population Census of Sudan 1993

Table (1) shows the economically active population in manufacturing in the northern states of Sudan. Only 2.5% of managers and professional and 1.5% of technicians and semi-professionals work in the manufacturing sector. This is considerably less than the sector's contribution to the economy and it unfortunately reflects the country's priorities. However, more emphasis on technical and professional manpower would be needed if the rehabilitation objects were to be achieved.

Manufacturing activities are highly concentrated in Khartoum and central regions. It was estimated in 1981/82 by UNIDO industrial census that these two regions accounted for about 55% of manufacturing establishments, 80% of total manufacturing employment and 75% of manufacturing gross output. Since the early 1980's the situation has not changed much, it is likely that the concentration has been even more prominent with the worsening economic situation hitting hardest the small-scale factories outside Khartoum and central region.

Table (2) shows the status of industry in Khartoum area in 1994. There were 1305 listed factories out of which 737 (56.5%) were operating, 336 (25.7 %) were out of operation, 126 (9.7%) were under construction and in 106 cases there was a license from authorities but construction was not yet started.

Table (2): The status of manufacturing activities in Khartoum state by industrial sub-sector in 1994

Sub-sector	Operating	Out of operating	Under construct	Licensed	Total
Food Industry	188	104	31	26	349
Textile Industry	85	55	28	10	178
Wood Products	18	12	4	4	38
Paper Products	50	19	5	12	86
Chemicals	109	66	22	11	208
Non-Metallic Minerals	50	14	8	18	90
Metals & Metal Products	74	46	16	15	151
Services	163	20	12	10	205
Total	**737**	**336**	**126**	**106**	**1305**

Source: Ministry of industry

Table (3): The Status of Manufacturing activities in Khartoum State by Industrial sub-sector in 1997-1998

Activity	Operating	Out of operating	Under construct	Licensed	Total
Food industry	227	128	36	40	431
Textile industry	52	72	9	119	252
Wood & wood products	73	24	6	46	149
Paper products & printing	50	11	3	21	85
Chemicals	166	71	10	157	404
Non-metallic Minerals	75	35	3	6	119
Basic Metal industry	20	19	3	3	45
Metals & Metal products	11	9	2	6	28
Total	**674**	**369**	**72**	**398**	**1513**

Source: Ministry of industry

Table 1.3 shows the status of industry in Khartoum area in 1997-1998. There were 1513 listed factories of which 674 (44.5%) were operating, 369 (24.4%) were out of operation, 72 (4.8%) were under construction and in 398 cases there was a license from authorities but construction was not yet started.

The role of the industrial sector has been minor in economy of Sudan and the performance of the industrial sector has been unsatisfactory with the growth of the industrial sector lagging behind the overall average economic growth. The contribution of manufacturing sector has been around 9% in the recent years & it has employed around 5% of the working force. Limited inter- and intra-industry linkages, high dependency on agricultural inputs and the narrowness and shallowness of the industrial base with low up-stream investments and minimal diversification characterize the industrial sector (Ministry of Industry & ministry of finance, 1995).

1.5 Statement of the Problem:

- No sewerage system in the area.
- Large quantities of industrial effluents are disposed of without treatment.
- The absence of an effectively authorized body or agency to look after the quality and characteristic of industrial effluents.
- Lack of awareness, lack of coordination, lack of effective legislation enforcement, lack of managerial and budgetary autonomy.

1.6 Study Area:

Description of the Study Area:

The 1993 Census shows that about 25 million people live in the Sudan and the estimation for 2002 is about 30 million.

Greater Khartoum is among the cities of the world that are growing most rapidly: it was six times bigger in 1983 than in 1956. At this rate the population of the city will be more than nine million by 2010. Rapid population growth & migration to urban area complicate the development challenges facing the Sudan. Khartoum lies at the middle of the country at the interception of 15°36′ N, 32°32′ E latitude and longitude respectively, and altitude of 386 meters (UNIDO, 1983).

Climate of the Study Area:

The temperature ranges from 6.2°C – 47.5°C, relative humidity 28%, average rainfall (1971-2000) is 121.4mm. Wind directions during winter in Northerly, during summer in southwesterly. Wind speed ranging 7-12 m.p.H.

1.7 Industry in Omdurman:

Industry in Omdurman is growing fast. It is controlled through an industrial committee. Various types of industries can be found ranging from handicraft, warehouse to medium industrial plants.

The infrastructure is partial available in Omdurman industrial area. The factories are surrounded by residential area, adequate transport facilities and market for industrial products in the Omdurman. The development of industry trend towards large industrial enterprises, and more diversified activities are created.

1.8 Objectives:

General Objective:

To assess the industrial liquid waste management in Omdurman industrial Area.

Specific Objectives:

1. To Qualify and quantify the liquid waste from the selected factories in study area.
2. To compare the obtained results with local standards.
3. To evaluate the existing waste disposal practices.
4. To determine the effects of the wastes on the environment.

Chapter Two

2

Literature Review

Chapter Two

Literature Review

2.1 Source of Industrial Pollution:

Industrialization and concentration of population in selected pockets of a country bring, in their wake, large quantities of industrial and sewage wastes that find their way into either the air or natural water bodies. This has been the case in the industrialized west where the quality of air & water has been continuously deteriorating and all efforts for pollution control have failed to restore the original purity of the air and water (S. P., 1991).

The following factors determine the type and level of industrial pollution (WHO report):

1. Type and amount of product manufactured and manufacturing Process used.
2. Type, amount and content of raw material used
3. The use of energy, water and air.
4. Size of the facility
5. Amount of toxic material stored on site
6. Quality and efficiency of abatement technology
7. Plant location
8. Others

2.2 Industrial Wastes:

Definition:

The industrial waste varies considerably in composition and concentration. It varies from industry to industry, within the same type of industry and even in a single plant. It requires individual evaluation and assessment.

Industrial waste can be classified in one or all of the following forms:

- Solid waste
- Liquid waste
- Gaseous waste

2.2.1 Industrial Solid Wastes:

The term "industrial solid wastes" is applied to unwanted or discarded waste material arising from industrial activities (Park, 1997).

These wastes include any discarded industrial material resulting from an industrial operation or establishment with the exception of dissolved or suspended solids in wastewater.

The quality and composition of industrial solid wastes vary significantly, from place to place as well as among industries in the same place, and even among industrial plants in the same industrial category (Mohamed, 1999).

Effect of Solid Waste:

As solid wastes are heterogeneous in nature (degradable and non degradable), their impacts on the pollution problem are many.

The accumulation of solid wastes in man's environment constitutes a positive health hazard because of the following reasons (Park, 1997):

i. The organic portion of solid wastes ferments and favours fly breeding.

ii. The pathogens may be conveyed to man through flies and dust.

iii. There is possibility of water pollution if rainwater passes through dumping area it might wash or dissolve the chemicals or Microorganisms and take them to water sources.

iv. There is the risk of air pollution, if there is accidental or spontaneous combustion of the waste.

v. Piles of refuse (solid wastes) are a nuisance from an aesthetic point of view.

Solid waste treatment and disposal:

There is no single method of solid wastes disposal which is equally suitable in all circumstances. The choice off a particular method is governed by local factors such as cost and availability of land and labour. The principal methods of solid wastes disposal are:

- Dumping
- Controlled tipping or sanitary land-fill
- Incineration
- Composting
- Manure pits
- Burial

2.2.2 Industrial Gaseous Wastes:

Air pollutants are substances in the atmosphere that have harmful effects. For millions of years, volcanoes, fires, and dust storms have sent smoke and other pollutants into the atmosphere coniferous trees & other plant emit volatile organic compounds into the air around them. There are mechanisms in the biosphere that remove, assimilate, and recycle these natural pollutants (Nebel & Wright, 1999).

Organisms are able to deal with certain levels of pollutants without suffering ill effects. The pollutant level below which no ill effects are observed is called the threshold level.

Three factors determine the level of air pollution:

- Amount of the pollutants entering the air
- Amount of space into which the pollutants are dispersed.
- Mechanisms that remove pollutants from the air.

The major sources of air pollution in the industrial areas are the gaseous wastes which come from the combustion of fossil fuels, some of the manufacturing processes and solid waste burning.

Air pollutants are direct and indirect by products of the burning of coal, gasoline, other liquid fuels, and refuse.

Suspended particulate matter, and volatile organic compounds (VOC_s), carbon monoxide, Nitrogen oxides (No_x), sulfur oxides (So_x) and lead are called primary pollutants because they are the direct products of combustion and evaporation.

Some of the primary pollutants may undergo further reactions in the atmosphere and produce additional undesirable compounds. The latter products are called secondary pollutants (e.g. Ozone, sulfuric and nitric acids).

Air pollution sources and types are different from industry to industry and within the same plant from hour to hour and from place to place.

Air pollution affects humans, animals, plants and materials. The relevant problems associated with air pollution are:

i. Effects on human health and hazards such as chronic bronchi and other respiratory diseases and toxicity for human being.

ii. Effects on materials and aesthetics.

iii. Plant damages and animal harming

iv. At the global issue air pollution leads to global warming and ozone layer depletion.

Air pollution control can be done, by improved combustion, control devices or using filtration media e.g. cyclone precipitator, electrostatic precipitator, bag house.

2.2.3 **Industrial Liquid Wastes:**

It is referred to as wastewater. These kind of pollution occurs due to the presence of dissolved inorganic materials, organic materials such as proteins, fats, carbohydrates and other substances found in industrial waters, and physical factors such as turbidity, color, temperature of effluent, associated radioactivity, etc (S. P., 1991).

In order to minimize problems, risks, wasted matter & energy contained in the industrial wastes, treatment is needed, or to increase the efficiency & profitability of industry (Elhaj, 1984).

The process is usually carried to promote waste quality in order to reduce its effect on human health & environment.

Pollution can be controlled by a proper choice of preventive & remedial measures. Good house keeping and maintenance of process equipment of a long way towards reducing pollution of water and air and increasing the life of the plant.

2.2.3.1 **Waste-water treatment basically involves two sets of measures**:

1. Preventive
2. Curative.

The preventive steps are made up of:

i. Volume reduction.

ii. Strength reduction.

Volume reduction achieved by the following:

a) Conservation of water used in the process

b) Segregation of different streams in the process.

c) Recycling and re-using water used in the process

d) Changing the production schedule to decrease wastewater produced.

e) Avoiding slug or batch discharges.

Strength reduction achieved by:

i. Equipment modifications and process changes

ii. Segregation, equalization and proportion

iii. Recovery of important by products from waste streams.

Curative measures deal with the actual treatment of liquid effluents by physical, chemical and biological methods, or their combinations, depending on the nature of the pollutants in the waste and the extent to which they are to be removed (S. P., 1991).

The degree to which treatment is required depends upon the mode of disposal of the treated waste. Different standards have been obtained for the discharge of effluents into natural water bodies, municipal sewers, and into the land.

According to wastes characteristics three methods of treatments were obtained: -

1) Physical methods, to remove solid or liquid pollutants, based on their density difference from water. They are essentially wastewater clarification methods and floating solids or liquids. Other physical methods of treatment are reverse osmosis, electro-dialysis, filtration, foam separation, filtration, adsorption, etc. They help remove fine particles and organic and inorganic dissolved materials, resulting in better water quality for re-use or disposal.

2) Chemical treatment, which traditionally involves coagulation, flocculation and precipitation to reuse the organic and inorganic load by settling the sludge or precipitates, formed. Also other type of chemical treatment base on:

i. Neutralization before they discharged into water bodies or municipal sewers.

ii. Removal of poisonous substances

iii. Oxidation is used for killing pathogenic organisms

3) Biological Treatment:

In this method colloidal and dissolved solids are converted into settle able solids by microorganisms under favourable environmental conditions. Anaerobic treatment `takes in the total absence of Oxygen & is a rather slow process. However, highly concentrated waste can be handled by this method filtration, digestion and lagoon are some of its categories. Aerobic biological treatment methods include the following:

i. Active-sludge process

ii. Trickling-filter process

iii. Stabilization ponds

iv. Oxidation Ditch

v. Rotating biological contactors

vi. Sludge digestion

vii. Fluidized-Bed contactors

Liquid Waste Disposal:

According to (Eljak, 1989) the disposal options for industrial liquid waste include the following:

Effluents disposed to the municipal treatment plant for complete treatment.

On-site treatment, then discharged to municipal sewerage system.

In-plant treatment, based on separate treatment of individual waste components from the different sections.

Construction of different plant in the same area from which the wastes are neutralized and cannot need method of treated.

Final effluents and sludge can be disposed of by four alternatives:

i. Return to source

ii. Irrigation

iii. Land disposal and evaporation

iv. Recycling

Industrial Wastes Hazards:

We have 104 chemical elements in the periodic classification, of this 80 are metals. Only 17 of these are toxic include lead, Mercury, cadmium, chromium, etc.. Their toxicity varies with threshold limiting value. The different metals have different degrees of toxicity (Nebel & Wright, 1998). Also radioactive wastes are put in especial category named "hazardous" waste. These types of waste need special care for handling, treating and disposing of them. They must be isolated from contact with humans and must be stored in way, which prevent them from polluting the surrounding environment. Also special care must be taken when disposing them either by burning (to avoid the contaminate underground water) or storing them in drums (to avoid corrode the tankers).

Main industrial sources of these toxic wastes are the pulp and paper industries, petroleum industries, leather and tanning industries and asbestos manufacturing.

2.2.4 Waste Treatment Plants in Sudan:

There are only two main sewerage system in operation in Sudan at Khartoum and Khartoum North.

i) El Goaze sewage treatment plant non-operational.

ii) Khartoum sewage treatment plant:

The Khartoum sewage treatment plant is at Soba was constructed (1982- rehabilitated in 1992). It is operated for treating both domestic and industrial waste. The design capacity 31420 m^3/d.

iii) Khartoum North Treatment Plant:

Khartoum North is the major industrial area in the Sudan. The Plant was constructed during (1967-1971) and was planned to be completed in three phases. Phase 1: to handle industrial waste, Phase II: to handle the residential waste while Phase III is for any extensions. Only Phase 1 was completed. At present only the industrial sewerage system is installed including 300 factories only. The plant faces problems as the BOD reaches above 2000 mg/l, oil contents are very high and so is the pH. The amount of organic nutrients is very low for effective bacterial activities. Currently hazards are arising and neighboring lands are endangered phase one design capacity is 6 MGD (22700 m^3/d).

This system transports mixed industrial effluent to the treatment plant at Hag Yousif located some 5 km to the east of Khartoum North.

2.3 Legislation:

The environmental health Act 1975: controls the important aspects of water pollution but only in a general manner (Annex I). The environmental health Act 1999 (Annex II). The environmental protection Act 2001(Annex III in Arabic).

Industrial Local Order 1971 defines the characteristics of industrial waste that can be discharged into public sewers.

Some regulations already exist in Khartoum North in the form of industrial waste local order 1971 (Annex IV).

Although legislation is available for effluent control, lack of financial resources and trained personnel has meant that effective control of industrial effluent has not been achieved to data.

Chapter Three

3

Materials & Methods

Chapter Three

Materials and Methods

3. Methodology:

This study was carried during the academic year 2001/2002 in the city of Omdurman, on the industrial liquid wastes.

3.1 Study Area General Description:

The industry in Omdurman is distributed along two sites the old industrial area and the new industrial area, which are surrounded by residential areas Fig. (2). The factories for the study were selected from the old industrial area. The major industries are small enterprises such as workshops, warehouses, small factories and handicraft activities, large industrial plants such as soft drinks, oil mills , soap plants and warehouses Fig. (3).

3.1.1 Industries in Omdurman Area:

Various types of industries are found around Omdurman table (4)

The major industries are divided according to ISC into eight major subsectors. Each subsector was divided into the following industries:

1- Food Industry includes the following :

- Jams or Juices
- Biscuits & Sweets
- Edible Oil
- Flour mills
- Animal fodder

Table (4): The status of manufacturing activities in Omdurman by industrial sub-sector in 1997.

Industrial sector	Large established		Firm under construction	Licensed	Total
	Operating	Out of operating			
Food industry	94	52	7	18	171
Textile industry	31	50	7	56	144
Wood & wood products	22	4	5	21	52
Paper & paper product & printing	14	4	1	2	21
Chemical	95	38	7	92	232
Non metallic Mineral product	28	18	-	2	48
Basic metal industry	16	14	3	-	33
Metal & Metal Product	-	1	1	-	2
Total	300	181	31	191	703

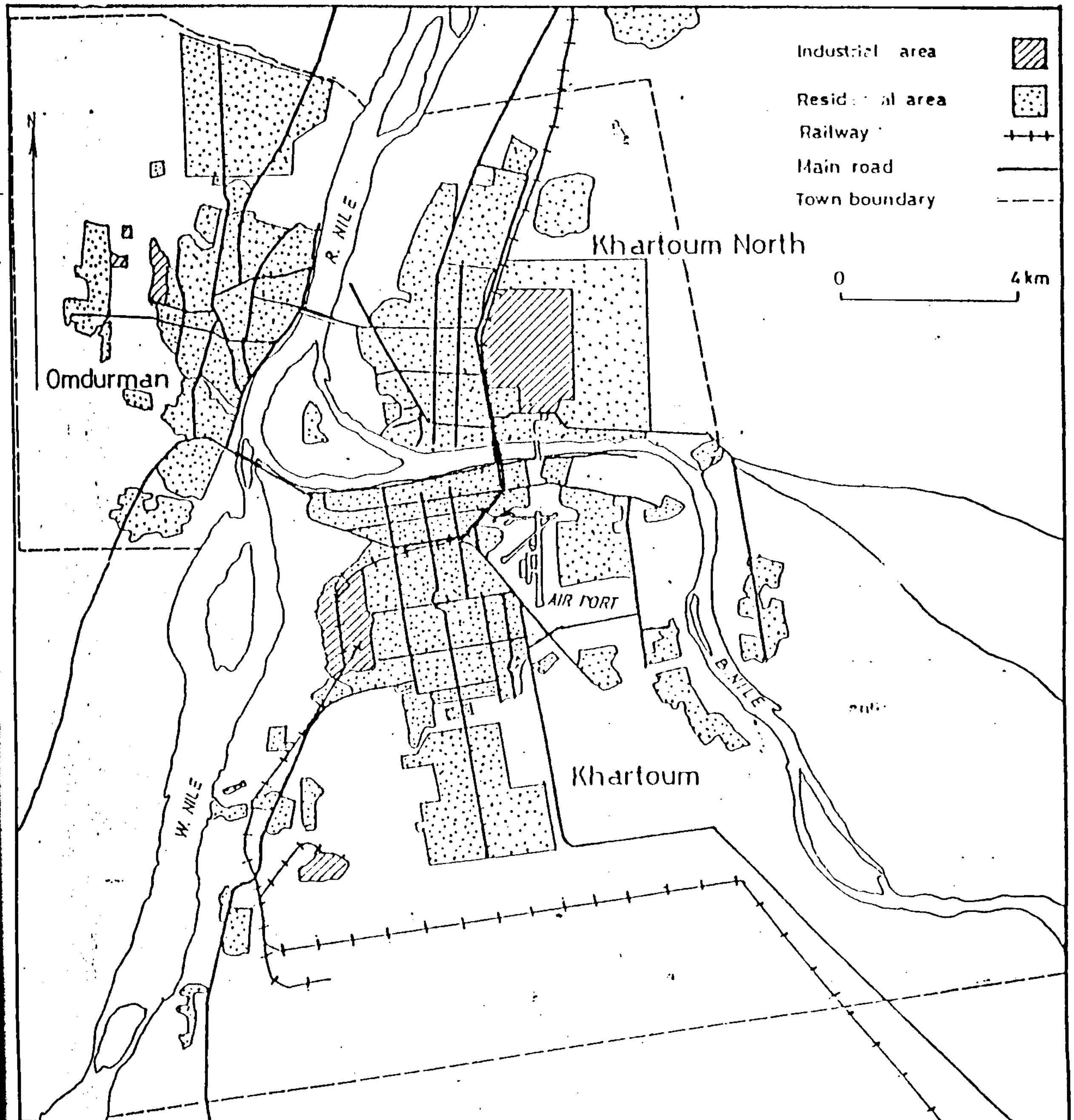
Source : Ministry of Industry

Small factory producing vinegar & Custard powder, Table (5) Shows industrial sub-sector in Omdudrman

Table (5): Subsector for food industry.

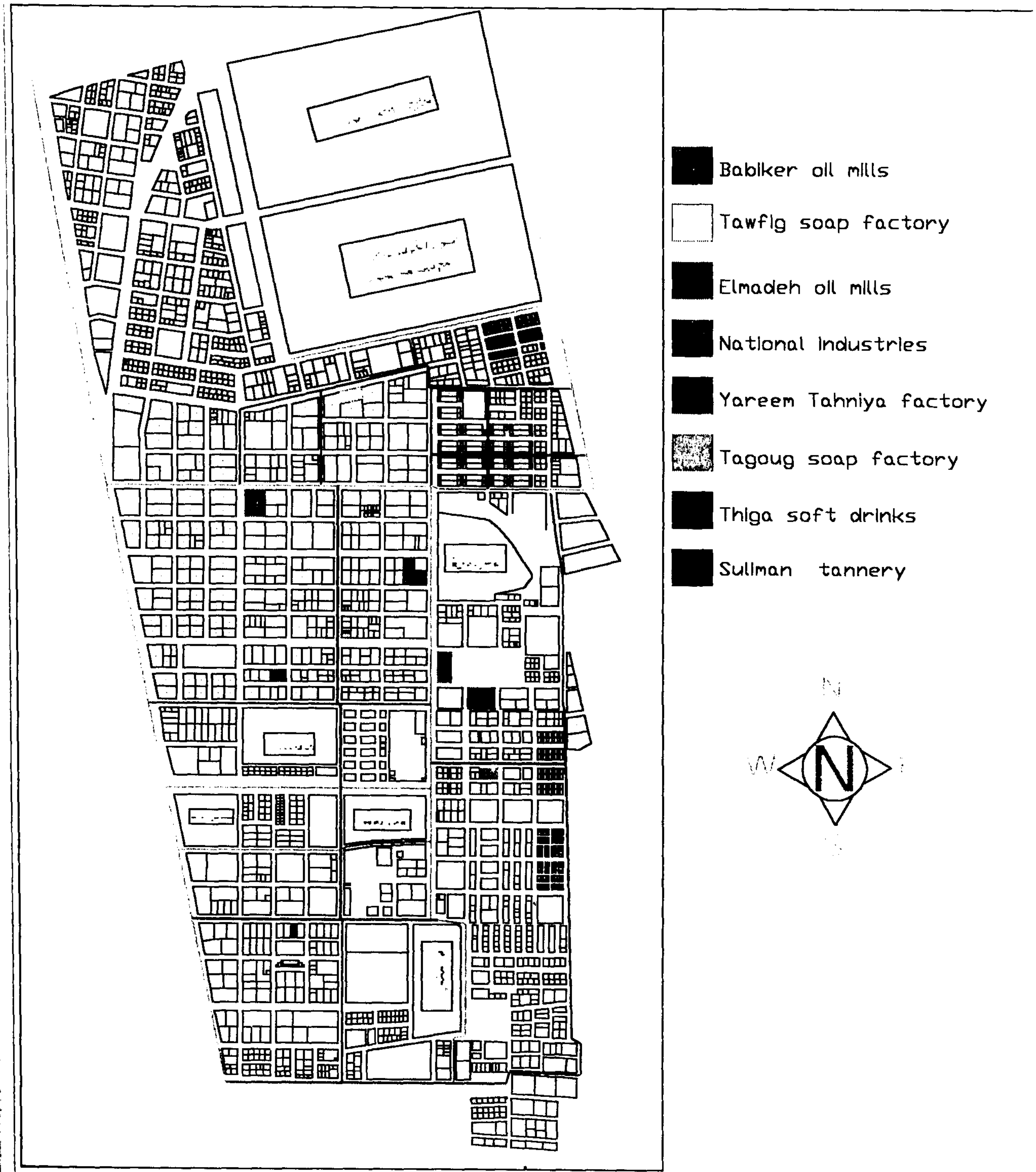
Subsector	Total
Sweet	**42**
Canning	**2 (out operation & under construction)**
Tahaniya	**20**
Edible oil	**20**
Jam & Beverage	**3**
Ice	**26**
Biscuits	**10**
Juices	**18**
Mills	**3**
Starch product	**20**
Animal fodder	**7**
Total	**171**

Fig (2) : The Three Towns



Source : Sudan Survey Department

Fig (3) : Omdurman Industrial Area



2- **Textile Industry:**

Textile industry is divided into the following group table (6)

Table (6) : Textile industry in Omdurman

Subsector	Total
Spinning textile	**92**
Tricot	**10**
Ready-made clothes	**35**
Tanneries	**6**
Leather Industry	**1 (under construction)**
Total	**144**

Other sectors:

3. Wood & Wood Product sector include 52 plant.
4. Paper & Paper Product and Printing include (20) Printing and (1) Carton which is under construction.
5. Chemicals sector : include the following : Soap, Plastic products, Paint, Cosmetics and Perfume, Wax and Medicine (under construction).
6. Non-Metallic products, include Floor-finishing, Glass, Silica, Marble and Synthetic Sponges.
7. Basic Metal industry,is included tin & Aluminum product.
8. Metals & Metal products sector is included the refrigerator plant .

According to the above sectors & subsectors of activities the selected industries are listed in table (7).

Table (7): Selected industries

Industrial Sector	Operating	Out of operation	Under construction	Licensed	Total
Oil Mills	14	4	1	1	**20**
Soap	13	9	1	49	**72**
Soft drinks	1	1	-	-	**2**
Tahnia	13	3	2	2	**20**
Tanneriers	3	2	1	-	**6**

The plants were selected according to the total number of operating plants for each sector. When the total number of operating is less than five units one plant was chosen and when the number is greater than five units, two plants were selected.

3.2 Material:

The industrial waste from the selected plants was considered with special emphasis on liquid waste because of it's great effect on the environment.

3.2.1 Methods Used:

1. Field surveys, physical visits to the selected factories and data collection.
2. Questionnaires (1,2).
3. Experimental work.
4. Statistical analysis.

3.3 Survey & Data Collection:

Data about existing plants were collected from many sources, namely, the field survey and physical visits to the selected factories, Ministry of Industry, UNIDO, Public Electricity, Water supplies, Investment, Urban Planning and Khartoum Sewage Treatment Plant.

Questionnaires:

This was carried through two separate forms Appendix (V). Questionnaire (1) is divided into 3 sections, section one addresses the plant managers, section two addersses the technical section about the plant & section three is economical section.

3.4 Waste Water Collection & Handling:

Samples of wastewater were collected from the selected plants, from the last manhole.

At first the proposed number of samples was three per plant, but at the beginning of the study the problem of shortage of raw materials; faced the oil mills. So the frequency of sampling was a sample every 10 days per plant.

3.5 Liquid Waste Analysis :

The liquid wastes sampled & analyzed for their physical & chemical characteristic in accordance with Standard Methods (American Public Health Association, American Water Works Association & Water Pollution Control Federation, 1989).

3.6 Physical Examination of Liquid Wastes:

The physical characteristics were determined after Cleslerri, L., S. (1989). Temperature was measured immediately at sampling time; using a mercury thermometer in degrees centigrade, & the pH value by electric pH-meter & conductivity by conductivity-meter, odour and colour by (Human sense).

The solids D.S & S.S were determined according to methods (2540 C & 2540 D) respectively.

3.7 Chemical Examination of Liquid Wastes:

The organic matter investigations were done as described by Greenberg Arnold F., 1989). The tests carried are BOD by method (5210B). In the case of dissolved oxygen (DO) method (4500); the azide modification method was used, COD was tested in accordance to method (5220B). The method (G5-40) was used for oil and grease (Link W.E, 1997).

Metal Determination:

The metal tested here was chromium . The Chromium was determined according to method (3500-Cr D), using Colorimetric equipment.

Liquid waste investigation:

The amount of liquid waste was calculated from the daily waste disposal. Field trips and visits to dumping areas were carried out in addition to the available records or estimates from the concerned departments. The waste disposal labourers, were also interviewed, to Know the amount of waste disposed.

3.8 Statistical Analysis:

Statistical package for social sciences (SPSS) software was used for the analysis.

Chi-square-test was used to estimate the relationship between Disease and type of industries, Disease and the work period, Disease and education level and Disease and age.

Chapter Four

4

Results

Chapter Four

Results

4.1 Selected Industries:

In this study, eight industrial units were selected table (8). General information such as date of establishment, investment, area, employment and power sources of these industries is presented in table (9). Some of the studied industries employ waste handling labourers as seen in table (10) services and help are provided by some industries. The common occupational diseases are shown in Fig. (4)

Industrial Waste Matter:

Each of the selected factories was taken independently to reflect the quantity and composition of wastewater produced.

4.1.1 Elmadeh Oil Mills:

Elmadeh Oil Mills table (9) is a private sector enterprise for edible oil production, in which crushing and extraction of oil seeds is used. It includes seed sorting and cleaning section Fig. (5).

The factory produces 3600-ton/year. Oil, with peak production during summer. It processes cottonseeds. The factory works 180 day/year based on two shifts per day. The daily production is 20 ton of oil as main product and the byproduct is the cakes.

Table (8): Selected factories and their final products

Industrial Unit	Final Product
1- Elmadeh Oil Mills Co. LTD	Edible Oils
2- Babiker Oil Mills	Edible Oils
3- Suliman Tannery	Skins Tanning
4- Nile Soft Drinks Bottling Factory	Stim and Maza
5- Tagoug Soap Factory	Soap and related products
6- Tawfig Soap Factory	Soap and related products
7-National Industries Sweets and Biscuits	Tahnia and Sweets
8- Yareem Tahnia Factory	Tahnia

Table (9): General information about the studied factories

Industrial Unit	Commission date	Area (m2)	Capital (SD million)	Employment		Fuel gal/d
				Total	Sweepers	
1- Elmadeh Oil Mills	1964	14000	105	50	1	700
2- Babiker Oil Mills	1997	8000	100	60	2	444
3- Suliman Tannery	1997	1250	5	12	5	20
4- Nile Soft Drinks	1998	2240	800	170	10	990
5- Tagoug Soap	1995	2400	90	52	10	667
6- Tawfig Soap	1979	4000	71	88	8	670
7- National industries	1968	4200	30	90	4	242
8- Yareem Tahnia	1999	2000	25	25	6	200
Total		**38090**	**1226**	**547**	**46**	**3933**

Table (10): Selected industries – waste handling workers – general information

Industrial Unit	Age (range)	Training	Services provided	Common Occupational diseases	Medical services &Comments
-Elmadeh Oil Mills	30	Skilled	Medical, meals, normal clothes	-	From insurance deposits (2 months has been working in waste disposal)
-Babiker Oil Mills	42	Skilled	Medical, transportation, meals	-	From insurance deposits (4 months has been working in waste disposal)
-Suliman Tannery	15-34	Skilled	Medical	Chest diseases, allergy & eye diseases	From insurance deposits
-Nile Soft Drinks	19-44	Skilled	Medical	-	From insurance deposits (2-3 months has been working in waste disposal)
-Tagoug Soap	53	Skilled	Medical, meals	Eye diseases	From insurance deposits
-Tawfig Soap	23-32	Skilled	Medical, transportation, normal clothes, meals	Back pain	From insurance deposits
-National Industries	17-56	Skilled	Medical	Chest diseases, leg muscles pain, eye diseases	From insurance deposits
-Yareem Tahnia	35	Skilled	Non	Headache	No insurance (2 months has been working in waste disposal)

Fig (4): Common Occupational Diseases among Waste Handling Workers

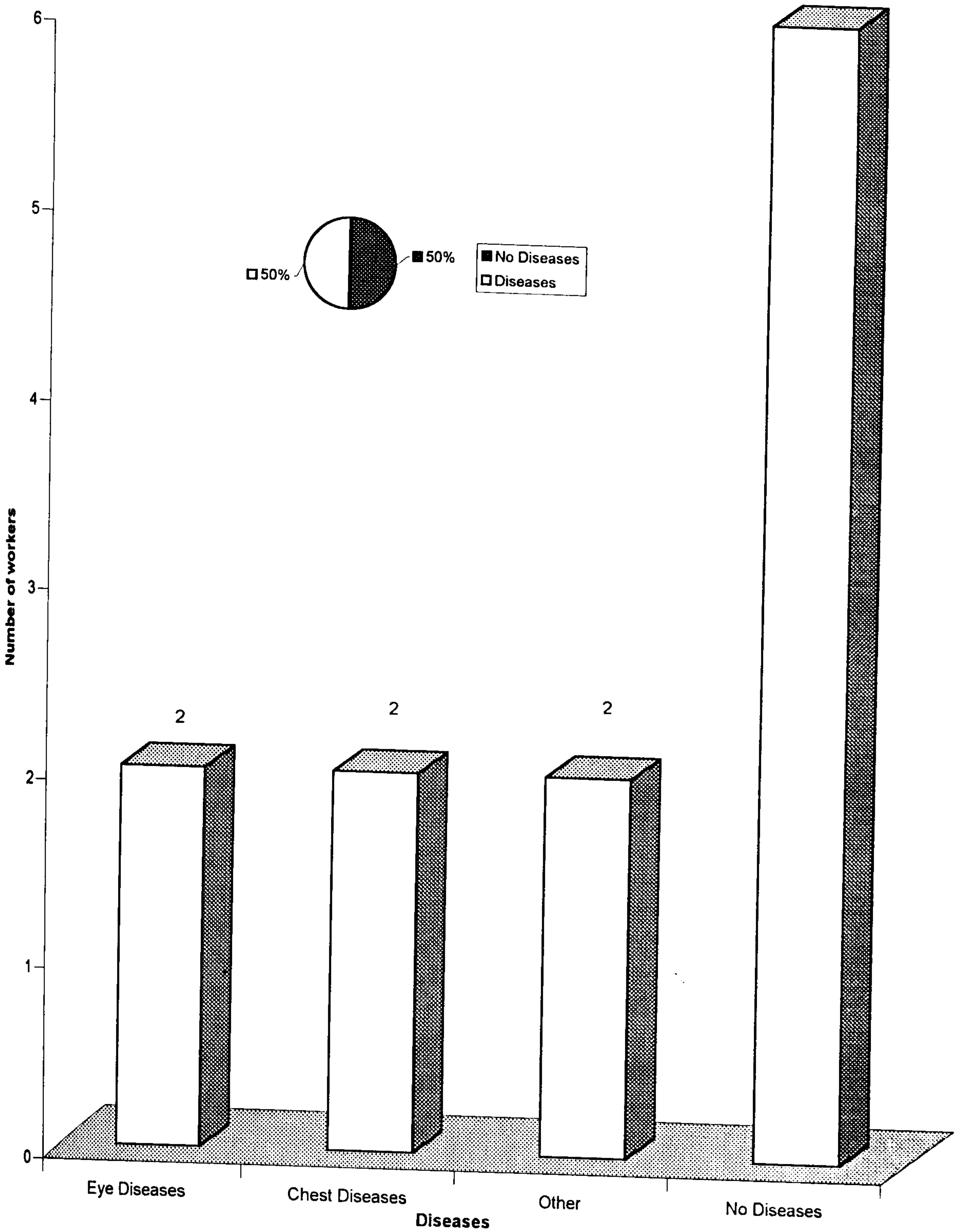
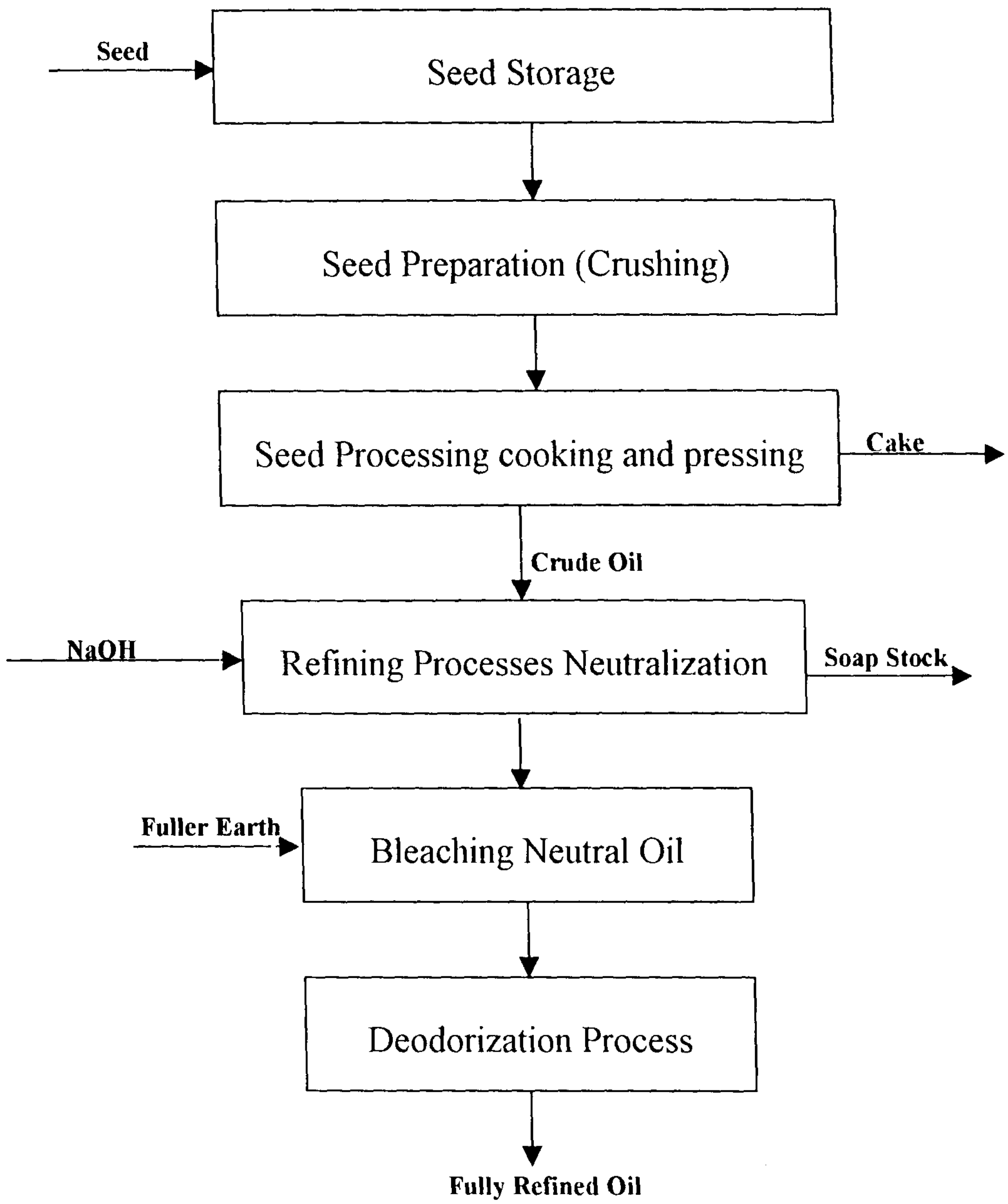


Fig. (5): Material Flow for Oil Seed Processing



Production Process:

The raw material used is the cotton seeds. Oil seed processing amounts to seed cleaning, crushing, cooking, and pressing, where 13% of oil is obtained from white seeds and 18% of oil is obtained from black seeds.

Factory Wastes:

The solid wastes generated from the cleaning of raw material and cake units. The solid wastes are disposed of on the land allotted by municipality.

The liquid waste is turbid, hot (40-51°C) and contains oils and soap stocks. It is disposed of on the land allotted by municipal authorities (located at the east of slaughterhouse of Ministry of Finance). The characteristics of the waste water are shown in table (11) and (12), which is varying with time as in Fig (6).

The liquid wastes are disposed of without treatment, Plate (1). Two boilers, emit directly into the environment, mainly gaseous wastes.

The factory has a generator 827 KVA and a water yard (Artesian well).

Storage:

Oil mills has adequate space for raw material storage and storage tanks having a total capacity of 2635 tons to store crude and refined oil Fig. (7).

Table (11): Studied Industries -Liquid Wastes Sources and Types

Industrial Unit	Origin of major wastes
- Elmadeh Oil Mills	Wash down process, oil spillage, solids from oil cakes, shells of raw seeds, cooling process, water, boilers, alkalis, oil refining, bleaching neutral oil, deodorization and maintenance oil
- Babiker Oil Mills	Wash down process, oil spillage, solids from oil cakes, cooling process, boilers, alkalis, refining and purifying process.
- Suliman Tannery	Skin tissues, proteins, hair, blood, dirt, fats, pigments, washing down process, salts & dyeing
- Nile Soft Drinks	Bottle washing, wash down process, cleaning of equipments, syrup-storage, tanks drain, sugars & liquid gases.
- Tagoug Soap	Was down of soap, soap purification, detergents, oil spillage, alkalies used with other salts, refining & saponifying of soap stack.
- Tawfig Soap	Wash down process, soap purification, detergents, alkalies used with other salts, saponifying of soap stack, glycerin, fatty acids and glycerol.
- National Industries	Washing of raw materials, cleaning of equipments, cooling & boilers.
- Yareem Tahnia	Wash down process, cooling, boilers, salts and cleaning of equipments.

Table (12): Elmadeh oil mills Co. LTD.
Flow rate (Q*) = 19.96 m^3/day

No.	parameters	Pollution load (Kg/d)			Mean	Range	Standard	Waste load Kg/1000Kg
		Min	Average	Max	mg/l	mg/l	deviation	Product
1	BOD(mg/l)	17.9	19.2	19.9	960.7	896-996	56.1	0.9202
2	COD (mg/l)	29.4	31.5	32.7	1574.3	1472-1936	89.2	1.508
3	Oil &grease(mg/l)	136.9	200.4	263.8	10018	6847-13189	3171	9.5958
4	T.S.(mg/l)	3342	3489.3	3606	174466.7	167100-180300	6732.3	167.114
5	T.D.S.(mg/l)	1770	1863.7	1884	91833.3	88500-94200	2970.4	87.963
6	T.S.S.(mg/l)	1572	1652.7	1722	82633.3	78600-86100	3782	79.151
7	Temp.(C0)	40	44.3	51	44.3	40-51	5.9	
8	pH	11.7		12.8		11.7-12.8		
9	Conductivity(mScm-1)	169.2	179.5	187.8	179.5	169.2-187.8	9.471	

Q* obtained from many sources, industry interviewer and public water office.

Fig.(6) Elmadeh Oil Mill Factory Fluctuation of BOD &COD of Waste.

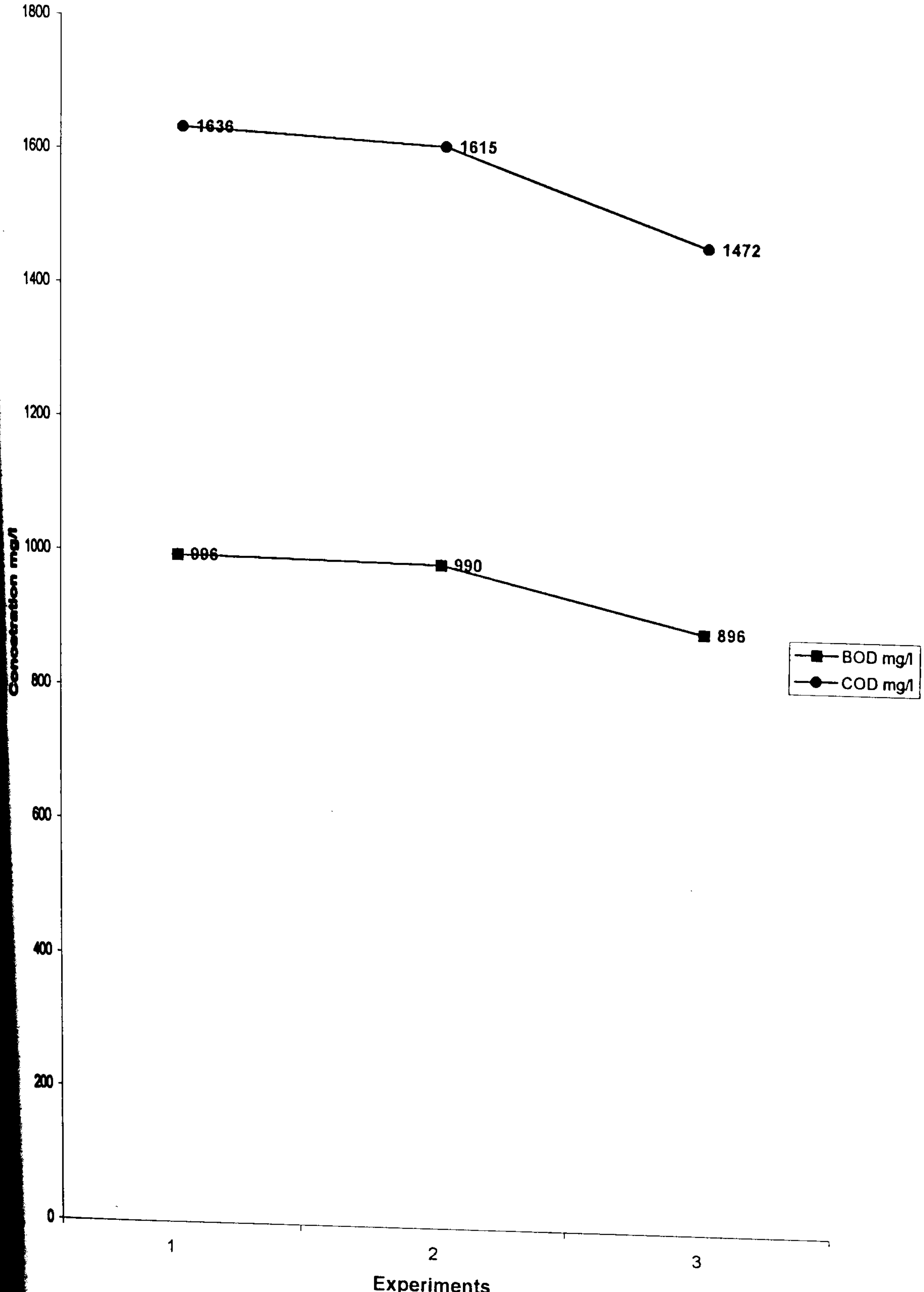
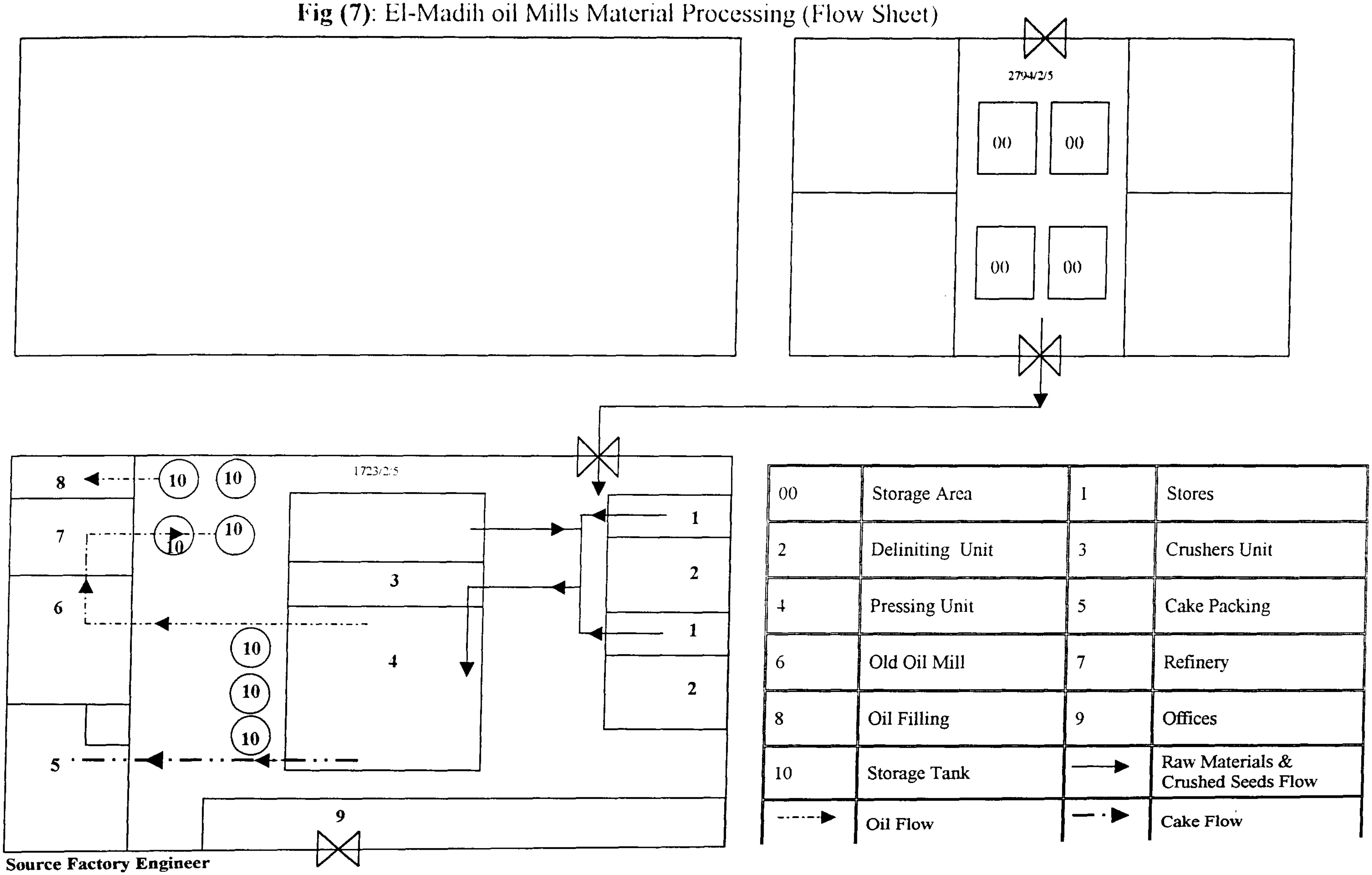


Fig (7): El-Madih oil Mills Material Processing (Flow Sheet)



00	Storage Area	1	Stores
2	Delinting Unit	3	Crushers Unit
4	Pressing Unit	5	Cake Packing
6	Old Oil Mill	7	Refinery
8	Oil Filling	9	Offices
10	Storage Tank	——▶	Raw Materials & Crushed Seeds Flow
‐‐‐‐·‐▶	Oil Flow	—·▶	Cake Flow

Source Factory Engineer

4.1.2 **Babiker Oil Mills:**

The Factory is a private sector venture, Table (9). The raw materials used are groundnuts, cotton seeds and caustic soda.

The factory produces 2916 ton/yr oil (cotton seeds) and 4800 ton/yr oil (groundnuts).

The factory works 180 day/yr on the basis of two shifts per day for oil from cotton seeds and works 300 day for oil from groundnuts.

4.1.2.1 Production Process:

Oil production involves seed preparation (crushing), seed pressing & crude oil neutralization and it was found to be within the range of 90-100 tons cotton seed per day. The Refining section constitutes of neutralization, bleaching and deodorization units.

4.1.2.2 Factory Wastes:

The solid wastes produced from sorting and cleaning of raw material and cake residue.

The liquid waste is turbid, hot (40-45°C). The liquid waste was collected into uncovered tanks then pumped to the lorry and disposed of on land.

The characteristics of wastewater are shown in Tables (11), (13) which is varying with time as in Fig. (8).

The gaseous wastes are mainly emitted by steam-train generator and emitting directly into the environment.

4.1.2.3 Storage:

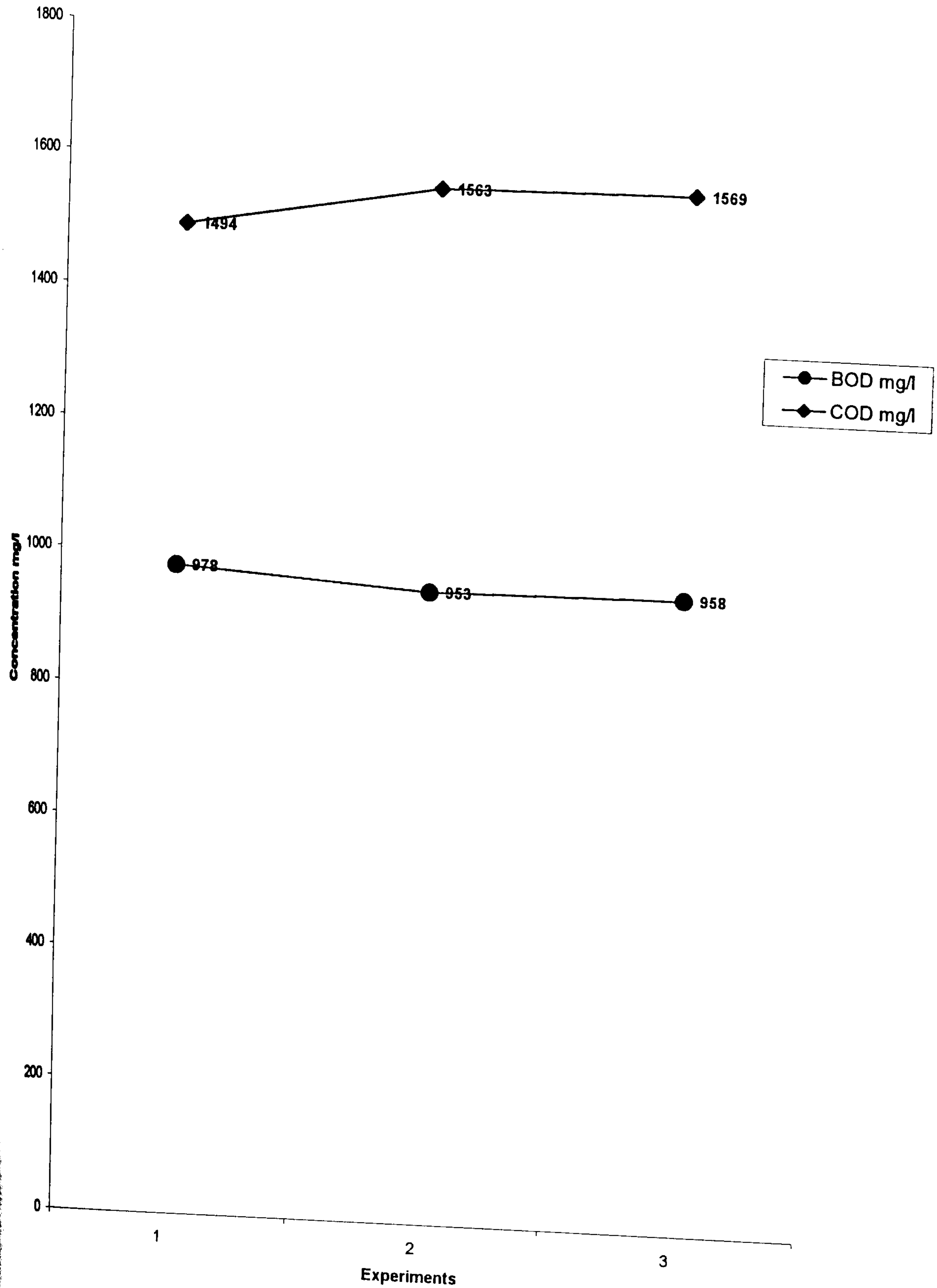
The oil mills has adequate space for raw material storage with two storage tanks having a total capacity of 600 tons store crude and refined oil.

Table (13): Babiker oil mills
Flow rate (Q*) = 15.45 m^3/day

No	parameters	Pollution load (Kg/day)			Mean mg/l	Range mg/l	Standard deviation	Waste load Kg/1000Kg Product
		Min	Average	Max				
1	BOD(mg/l)	11.44	11.6	11.74	963	953-978	13.23	0.7133
2	COD (mg/l)	18.77	18.9	19.13	1575.3	1563-1594	16.44	1.1669
3	Oil &grease(mg/l)	95.18	95.3	95.36	7939.3	7932-7947	7.51	5.881
4	T.S.(mg/l)	1684	1705.6	1729.2	142133	140300-144100	1903.5	105.28
5	T.D.S.(mg/l)	943.2	956	968.4	79667	78600--80700	1050.4	59.01
6	T.S.S.(mg/l)	740.4	869.6	1107.6	72467	61700-92300	17197	53.68
7	Temp.(C0)	40	42.3	45	42.3	40-45	2.5	
8	pH	9.4		10.1		9.4-10.1		
9	Conductivity(mScm-1)	158	161.2	163	161.2	158-163	2.8	

Q* obtained from many sources, industry interviewer and public water office.

Fig.(8) : Babiker Oill Mills Factory, Variation of BOD &COD of Waste



4.1.3 Tagoug Soap Factory:

It is a private company, which produce soap and glycerin. Normally the factory operates 300 days/yr. The raw material used are red palm stearin, caustic soda, salts, sodium silicate, essence for laundry soap.

The capacity of the Factory is 14000 cartons (45pieces/ carton) per day i.e. 97 ton/day.

4.1.3.1 Production Process:

As in Fig. (9) the raw material is mixed, boiled, solidified and lastly shaped to be packed into cartons.

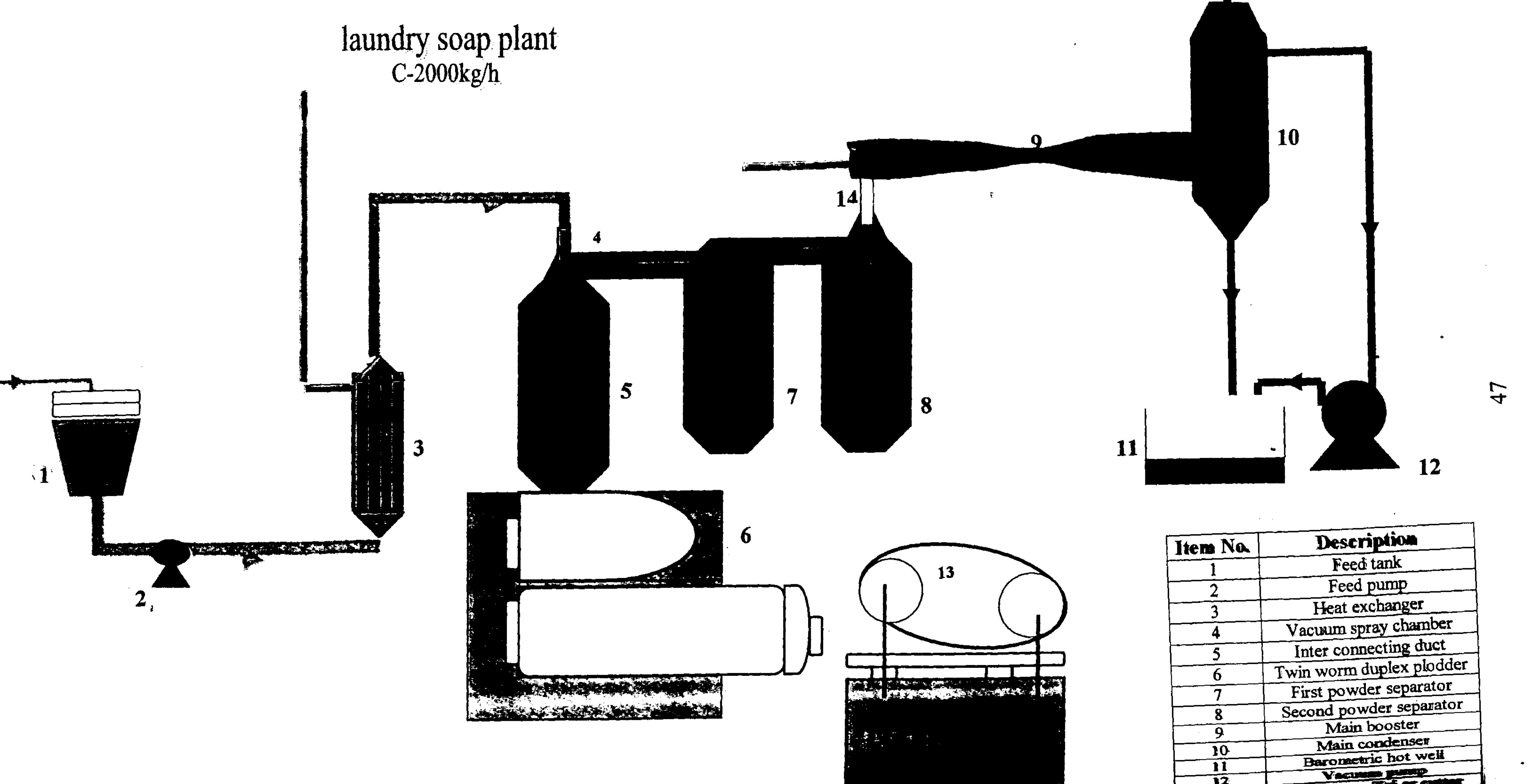
4.1.3.2 Factory Waste Matter:

The liquid waste source and characteristics are shown in Table (11), (14), which is varying with time as in Fig. (10).

The solid waste is constituted of soap pieces, soda, paper and container of raw material. The solid wastes first are sorted. Then parts of them are sold or reused and the other part is collected manually and disposed of on the land allotted by municipality.

The waste water is usually pumped to lorry tankers and disposed of on land plate (2) without any treatment. The production of glycerin is seasonally due to lack of equipment. The factory has a generator and a flow-meter, which does not match with the capacity of production.

Fig (9): Tagoug Soap Factory (Flow Sheet)



Item No.	Description
1	Feed tank
2	Feed pump
3	Heat exchanger
4	Vacuum spray chamber
5	Inter connecting duct
6	Twin worm duplex plodder
7	First powder separator
8	Second powder separator
9	Main booster
10	Main condenser
11	Barometric hot well
12	Vacuum pump
13	[illegible]
[illegible]	[illegible]

Table (14): Tagoug soap factory liquid waste characteristics
Flow rate (Q*) = 117.44 m^3/day

No.	parameters	Pollution load (Kg/d)			Mean mg/l	Range mg/l	Standard deviation	Waste load Kg/1000Kg product
		Min	Average	Max				
1	BOD(mg/l)	9.9	10	10	664.7	661-668	3.5	0.14
2	COD (mg/l)	13.8	13.9	14.1	929	918-941	11.5	0.19
3	Oil &grease(mg/l)	56.7	162.8	269	10855	3780-17930	7075	2.26
4	T.S.(mg/l)	1071	1162	1222.5	77467	71400-81500	5348.2	16.14
5	T.D.S.(mg/l)	597	630	651	42000	39800-43400	1928.7	8.75
6	T.S.S.(mg/l)	474	532	571.5	35467	31600-38100	3421	7.39
7	Temp.(C0)	62	70.3	76	70.3	62-76	7.4	
8	pH	10.7	12	12.8	12	10.7-12.8	1.1	
9	Conductivity (mScm-1)	62	70.3	76	70.3	62-76	7.4	

Q* obtained from many sources, industry interviewer and public water office.

Fig.(10) : Tagog Soap Factory Waste Variation of BOD & COD

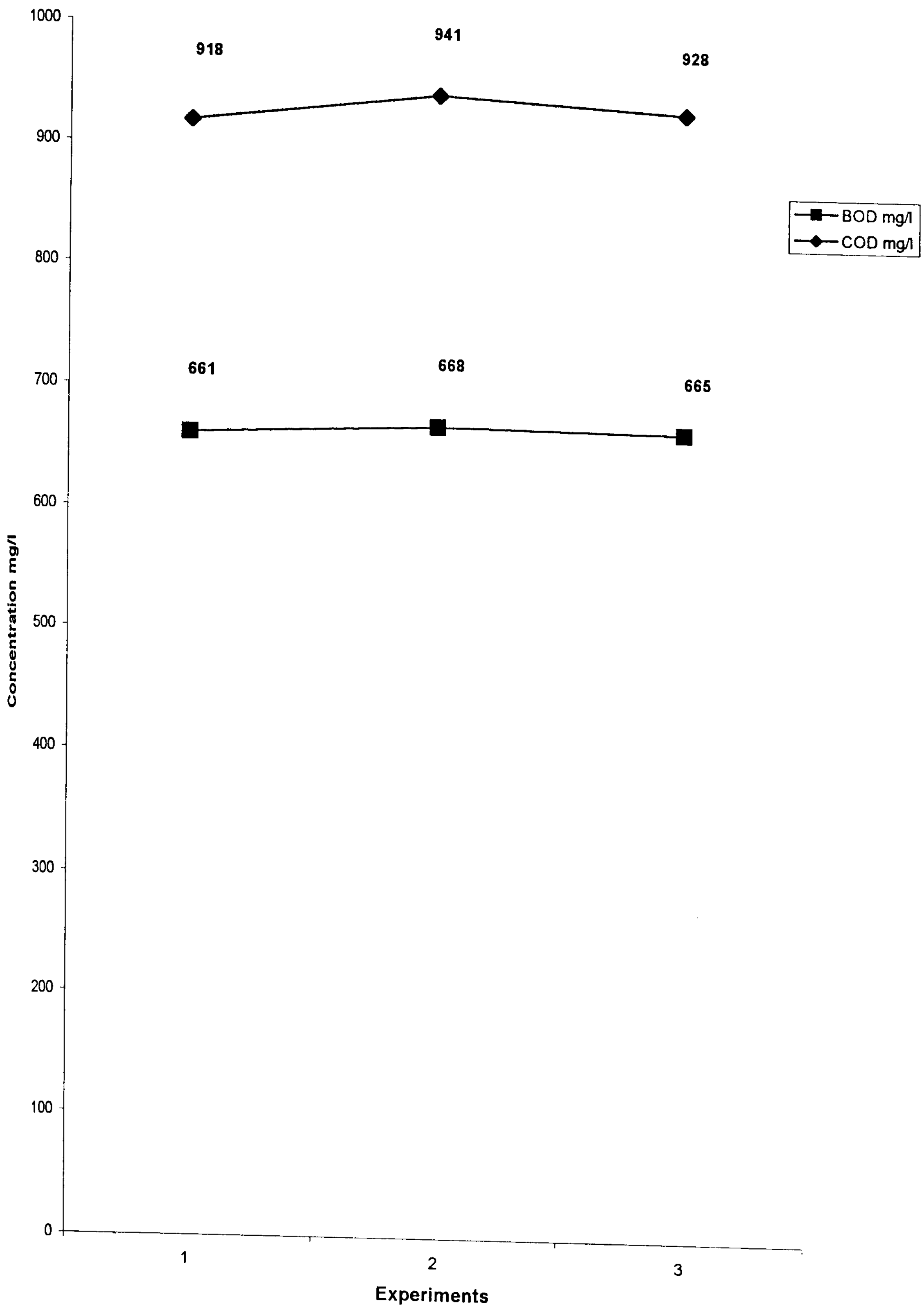


Plate (1): Wastewater site allotted by municipal authorities is located at the east of slaughterhouse of Ministry of finance (wastewater is disposed of from oil mills factory).

Plate (2): wastewater site allotted by municipal authorities near the Elmarkiat hills (wastewater which, is disposed of from soap, soft drinks, tannery and tahnia factories).

4.1.4 Tawfig Soap Factory:

Tawfig soap factory, Table (9), is a private sector for laundry soap and toleit soap. The raw material used are red palm stearin, caustic soda, salts, sodium silicate, essence .

The factory produces 21600 ton/yr of soap. The factory works 300 d/yr on the basis of two shifts per day.

Production Process:

As in Fig (11) the raw material is mixed , boiled, solidified and lastly shaped to be packed into cartons.

Factory Waste Matter:

The solid waste is constituted of soap pieces, paper and container of raw material. The solid wastes are collected manually and disposed of on the area allotted by municipality.

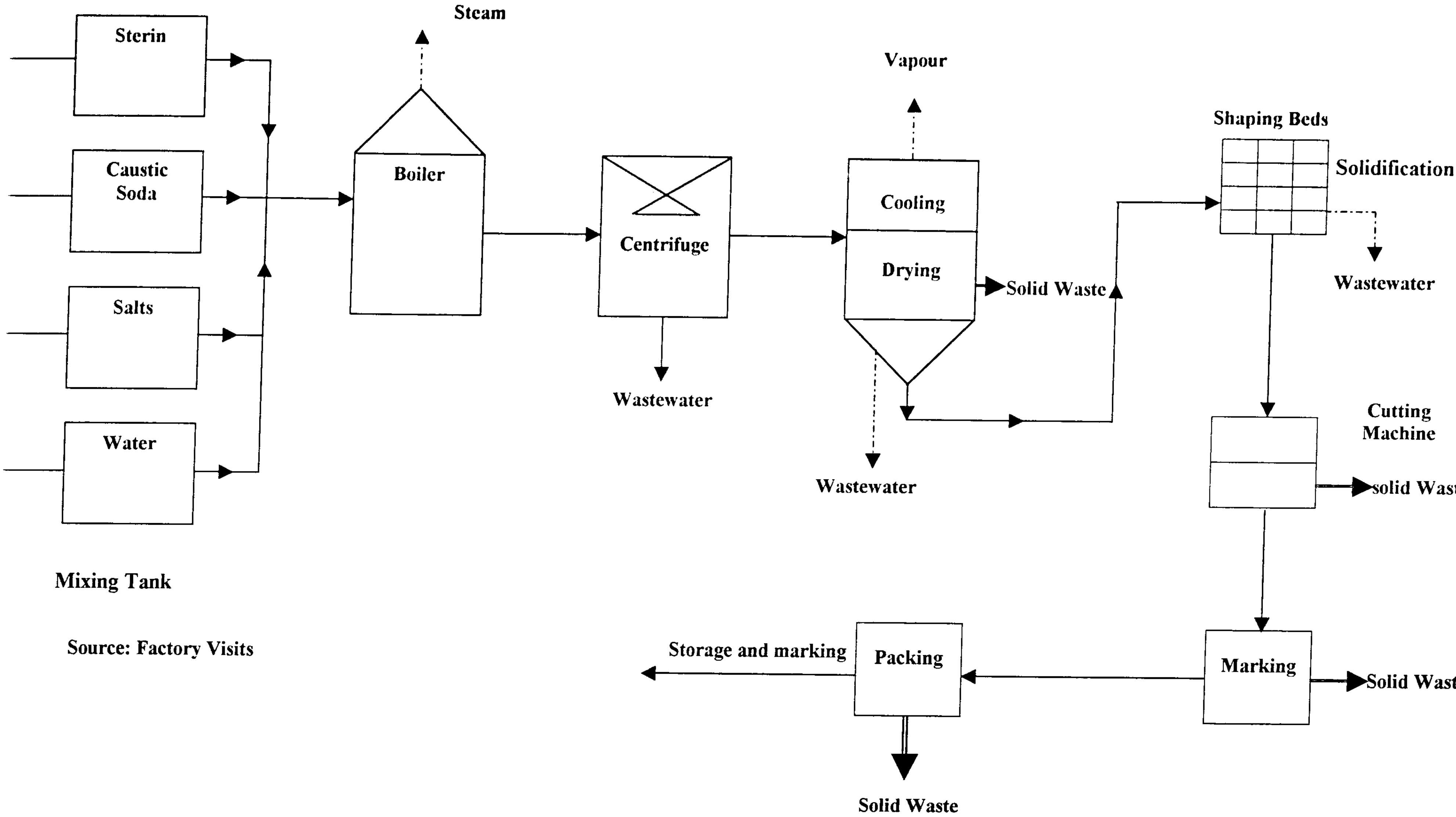
The characteristics of waste water and source are shown in Table (15), (11). The waste water is pumped and disposed of on land without any treatment.

4.1.5 Nile Soft Drinks:

It is private company, produces 84 tons of stim (336000 bottles) per day Table (9).

The factory works 300 day/yr on basis of two shift. The factory uses salts, sugar, water and concentrated as raw materials. The factory has a generator and a water yard (Artesian well).

Fig. (11): Tawfig soap factory



Source: Factory Visits

Table (15): Tawfig soap factory liquid waste characteristics
Flow rate (Q*) = 40 m^3/day

No.	parameters	Pollution load (Kg/d)			Mean mg/l	Range mg/l	Standard deviation	Waste load Kg/1000Kg product
		Min	Average	Max				
1	BOD(mg/l)	13.5	13.6	13.68	680	675-684	4.6	0.19
2	COD (mg/l)	19.4	19.5	19.7	975	968-985	8.9	0.27
3	Oil &grease(mg/l)	17.2	17.7	18.1	883.3	860-907	23.5	0.24
4	T.S.(mg/l)	1702	1766.7	1848	8833	85100-92400	3720.7	24.54
5	T.D.S.(mg/l)	904	954	992	47700	45200-49600	2260.5	13.25
6	T.S.S.(mg/l)	784	812.7	856	40633	39200-42800	1908.8	11.29
7	Temp.(C0)	47	49.7	55	49.7	47-55	4.6	
8	pH	10.4	11.3	12.6	11.3	10.4-12.6	1.2	
9	Conductivity (mScm-1)	88.2	91.6	97.4	91.6	88.2-97.4	5.1	

Q* obtained from many sources, industry interviewer and public water office.

Production Process:

Stim production is mainly mixing of the raw materials at certain ratios Fig (12). Cooled, mixed and then stoppered in bottles (24 bottle/box and 6 bottle/set of 2 liter in each bottle).

Factory Waste Materials:

For liquid wastes volume and characteristics are in Table (11),(16) and Fig (13). The waste water is directed to two septic tanks. The liquid wastes are disposed of without treatment. It is pumped and disposed of on land. Solid wastes are collected manually and disposed of on land plate (3, 4, 10).

4.1.6 Suliman *Tannery*:

It is a private sector, it was constructed in 1997. The sheep and goat skins used as raw material, mainly come from the Omdurman Province. Chemicals are used during the processes are hydrated lime, sodium sulphite, preventol, Arbon, sulphuric acid and salt, Amonium sulphate and chromium. The factory has a generator.

Production Process:

The raw materials is washed in drums with cold water to remove salt and dirt from skins Fig (14). Then is soaked in water with hydrated lime and sodium sulphide for 24 hours. The second process is unhairing and is done manually. The unhaired hide is defleshed mechanically i.e. the subcutaneous connective tissue flesh is removed. The third process is deliming and bating, organic acids are used to remove liming chemical or to neutralized and bating to removes pigments. Then pickling process, these are done 6 hours in Ammonium sulphite, sulfuric acid and salt solution and the chemical are mixed in different concentrations. The next step is tanning the skin and the last step, packing and export.

Fig. (12): Nile Soft Drinks Factory Material Processing (Flow sheet).

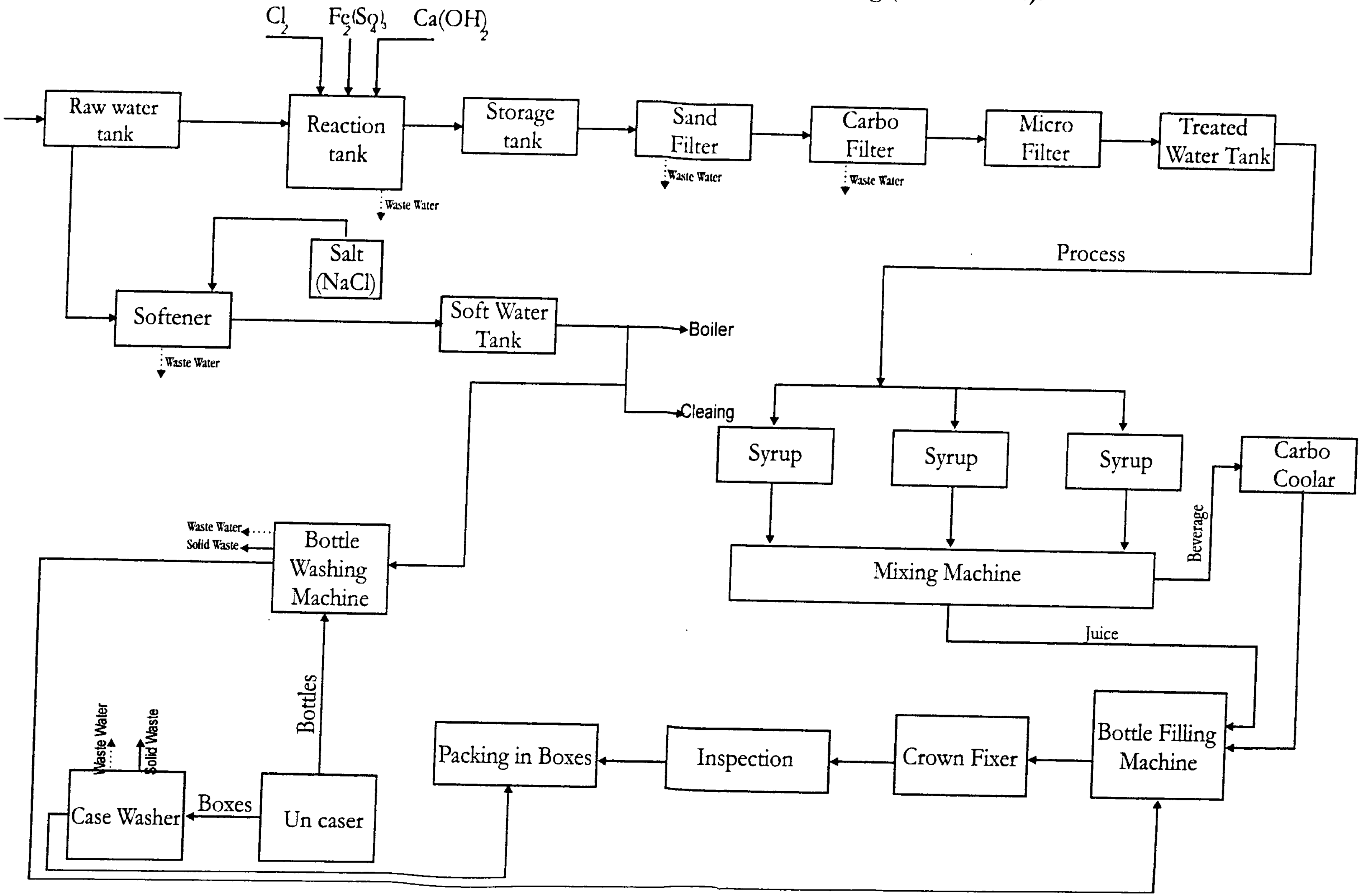


Table (16): Nile soft drinks bottling factory liquid waste characteristics
Flow rate (Q*) = 451.01 m^3/day

No.	parameters	Pollution load (Kg/d)			Mean mg/l	Range mg/l	Standard deviation	Waste load Kg/1000Kg product
		Min	Average	Max				
1	BOD(mg/l)	66	165.6	356.4	146.7	89.1-186	51	1.97
2	COD (mg/l)	81.2	201.3	438.4	175.5	109.6-214	57.4	2.4
3	T.S.(mg/l)	200	505.3	1080	453.3	270-590	165	6.02
4	T.D.S.(mg/l)	152	372	800	330	200-410	113.6	4.43
5	T.S.S.(mg/l)	48	133.3	280	123.3	70-180	55.1	1.59
6	Temp.(C0)	22	30	35	30	22-35	7	
7	pH	8.4	8.6	8.8	8.6	8.4-8.8	0.2	
8	Conductivity(mScm-1)	0.38	0.6	0.81	0.6	.38-.81	0.2	

Q* obtained from many sources, industry interviewer and public water office.

Fig.(13) : Nile Soft Drinks Bottling Factory Waste Variation of BOD&COD

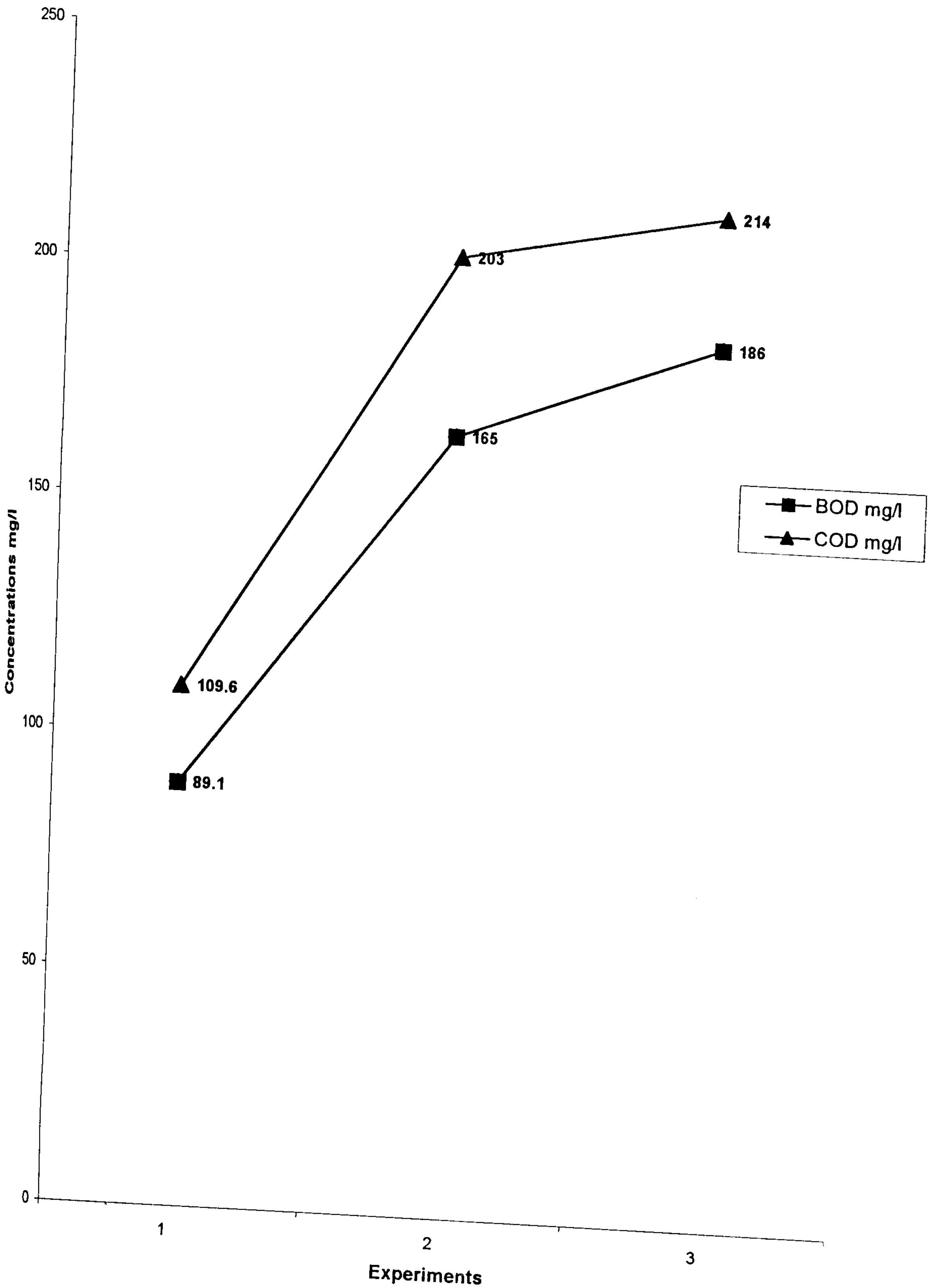
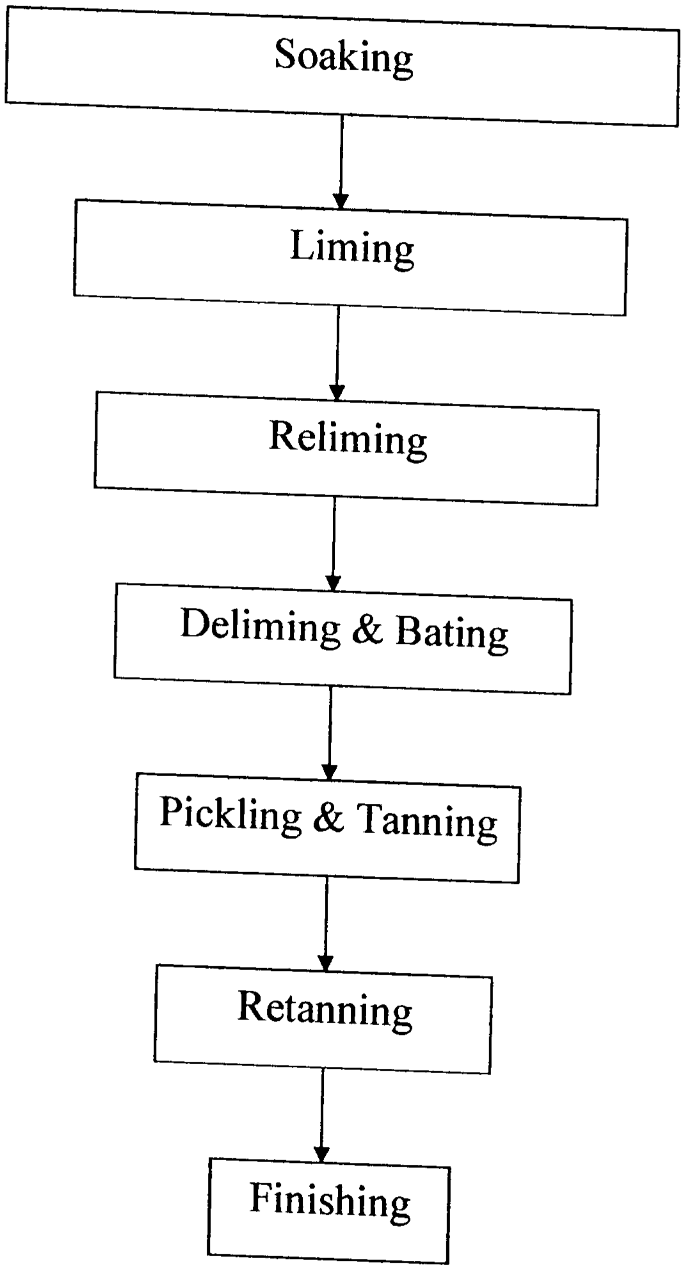


Plate (3): Garbage and rubbish generated by industrial activities Disposed of on the land allotted for wastewater.

Plate (4): Streets inside the industrial area over crowded With old dumplings for liquid and solid wastes, which have Affected the walls of one of the factories.

Fig (14) : Tannery Processing



Factory Waste Materials:

The volume and characteristics of liquid wastes produced are shown in Table (17). The wastes are collected in aseptic tank (pH 11.9). The liquid waste containing chemicals & particulate is pumped without treatment to open area. The solid wastes are collected manually, and disposed of on land, plate (9).

4.1.7 National Industries:

The factory is a company, Table (9) for sweets and Tahnia. It includes washing, sorting, cleaning, boiling and mixing. The factory produces 1036 ton/yr. Tahnia. The factory works 288 day/yr. on the basis of two shifts per day. The daily production is 3.6 tons of Tahnia.

Production Process:

The raw material sesame is cleaned and washed and soaked for 2 hours then subjected to salting, desalting, cooking, sieve and crushing. The Tahyna is obtained. Mixing of sugar and vanilia and sweet at certain ratios. The mixture is added to Tahyna, cooled, mixed and then packed in tins (15 kg/tin).

Factory Wastes:

The liquid waste is turbid, temperature (22°C) and contains dissolved and suspended solids. It is disposed of on land (open area). The characteristics of waste water are shown in Table (11), (18).

Storage:

Tahnia is stored in eight tanks with a capacity of 7.5 ton/each.

Table (17): Suliman tannery
Flow rate (Q*) = 34.47 m^3/day

No.	parameters	Pollution load (Kg/d)			Mean mg/l	Range mg/l	Standard deviation	Waste load Kg/1000Kg product
		Min	Average	Max				
1	BOD(mg/l)	30.78	31.1	31.5	973.3	962-984	11.02	4.67
2	COD (mg/l)	57.3	57.9	58.3	1808.7	1791-1821	15.7	8.68
3	T.S.(mg/l)	1004.8	1187	1360	37100	31400-42500	5556.1	178.08
4	T.D.S.(mg/l)	249.6	315.7	374.4	9866.7	7800-11700	1960.4	47.36
5	T.S.S.(mg/l)	755.2	871.5	985.6	27233	23600-30800	3600.5	130.72
6	Cr(mg/l)	0.1728	0.189	0.208	5.9	5.4-6.5	0.5568	0.02832
7	Temp.(C0)	22		25	24	22-25	1.732	
8	pH	11.8		12.1		11.8-12.1		
9	Conductivity(mScm-1)	15.9		24.8	20.3	15.9-24.8	4.451	

Q* obtained from many sources, industry interviewer and public water office.

Table (18): National industries sweetes and biscuits
Flow rate (Q*) = 22 m^3/day

No.	parameters	Pollution load (Kg/d)			Mean mg/l	Range mg/l	Standard deviation	Waste load Kg/1000Kg product
		Min	Average	Max				
1	BOD(mg/l)	19.44	19.6	19.7	978.7	972-986	7.02	1.63
2	COD (mg/l)	31.76	31.9	32.9	1594.7	1588-1605	9.07	2.66
3	T.S.(mg/l)	2890	2940	3016	147000	144500-150800	3345.15	245
4	T.D.S.(mg/l)	1594	1630	1650	81500	79700-82500	1562.05	135.83
5	T.S.S.(mg/l)	1268	1310	1366	65500	63400-68300	2523.89	109.17
6	Temp.(C0)	20	22	24	22	20-24	2	
7	pH	9.6	9.7	9.8	9.7	9.6-9.8	0.12	
8	Conductivity(mScm-1)	160.3	163.9	166.2	163.9	160.3-166.2	3.18	

Q* obtained from many sources, industry interviewer and public water office.

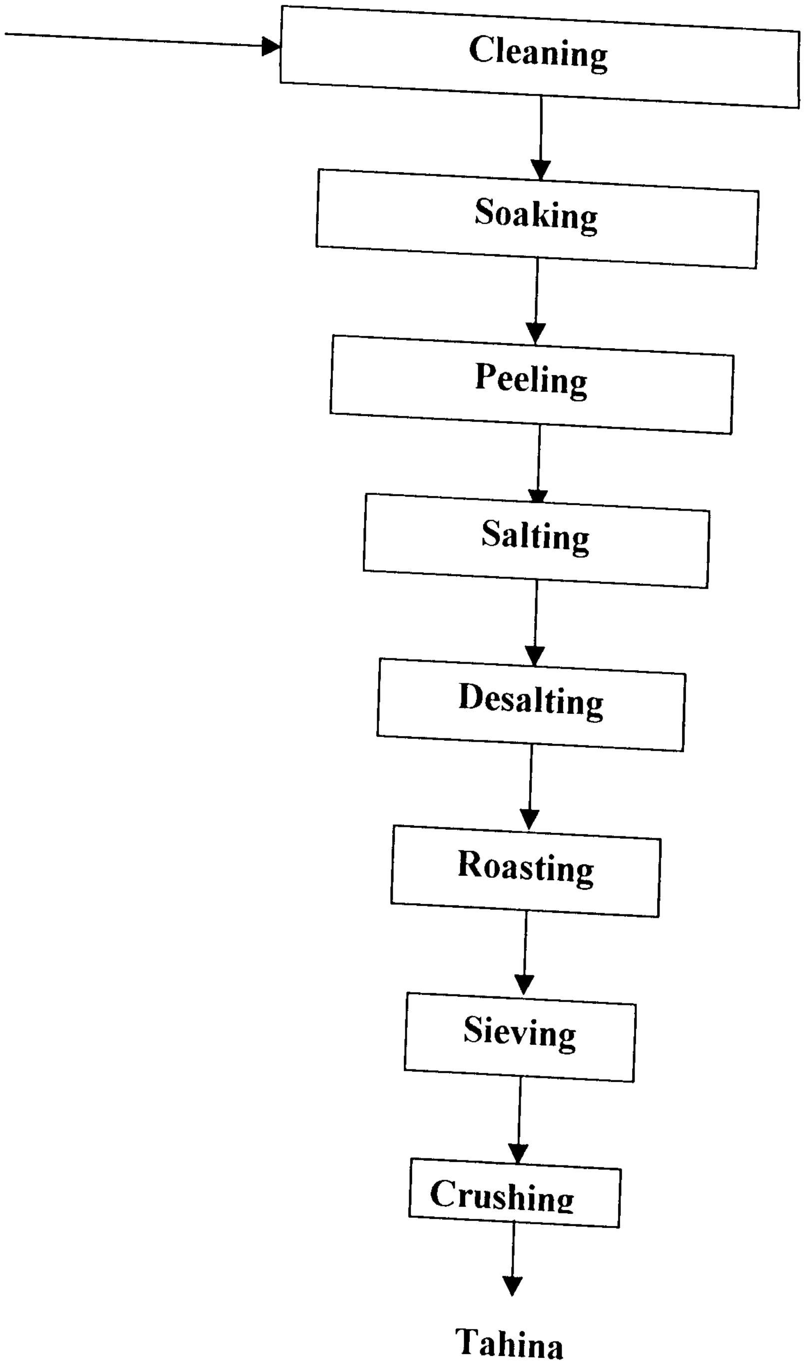
4.1.8 Yareem Tahnia:

This is a private company, Table (9) for Tahyna & Tahnia. The factory works 300 day/yr. on a one shift basis. The capacity of the factory is 3.5 ton/day. The factory uses sesame, sugar, glucose, sweet, vanillia , water as raw materials. The factory has a generator.

Production Process:

The raw sesame is subjected to cleaning, washing and soaking for 2 hours, peelings and salting, cooking, and crushing Fig. (15).

Fig. (15): Tahnia Processing



Tahnia production is based mainly on mixing of the raw materials at certain ratios, cooled and then packed.

Table (19): Yareem tahnia factory liquid waste characteristics
Flow rate (Q*) = 23 m^3/day

No.	parameters	Pollution load (Kg/d)			Mean mg/l	Range mg/l	Standard deviation	Waste load Kg/1000Kg product
		Min	Average	Max				
1	BOD(mg/l)	17.6	18.3	19.6	915	878-982	58.13	1.76
2	COD (mg/l)	28.2	29.5	31.6	1473.3	1412-1580	92.72	2.84
3	T.S.(mg/l)	2830	2980.7	3144	149033	141500-157200	7869.14	286.82
4	T.D.S.(mg/l)	1616	1675.3	1758	83767	80800-87900	3690.98	161.21
5	T.S.S.(mg/l)	1214	1485.3	1926	74267	60700-96300	19251.06	142.93
6	Temp.(C0)	23	24.3	25	24.3	23-25	1.15	
7	pH	9.6	9.9	10.3	9.9	9.6-10.3	0.36	
8	Conductivity(mScm-1)	161.9	168.17	176	168.2	161.9-175.9	7.11	

Q* obtained from many sources, industry interviewer and public water office.

Factory Wastes:

The liquid waste volume and characteristics are shown in Tables (11), (19) and Fig. (16).

It is disposed of on land without treatment. The solid waste are collected manually and disposed of on the area allotted by municipality.

4.1.9 Waste handling workers:

Age workers included in this study range between 15-56 mean $\pm$ S.E = 33.3 $\pm$ 3.91. 16.7% were non educated, 58.3% primary school educated, 16.7% high secondary school and 8.3% after secondary school. 58.3% were single and 41.7% were married.

Higher percentage of disease was observed among the tannery workers, the percentage of the disease among workers Tahnia and soap industries is lower. There is no disease was observed among the workers of soft drinks and oil mills industries Table (20), Fig (17).

Table (20) Type of industries and disease

Type of industries	**Disease**	
	Yes number (%)	**No number (%)**
Tannery	**2 (100)**	**0 (0)**
Soft Drinks	**0 (0)**	**1 (33.3)**
Tahnia	**2 (66.7)**	**1 (33.3)**
Oil Mills	**0 (0)**	**2 (100)**
Soap	**2 (66.7)**	**1 (33.3)**

Fig(16) : Yareem Tahnia Factory Waste Variation of BOD & COD

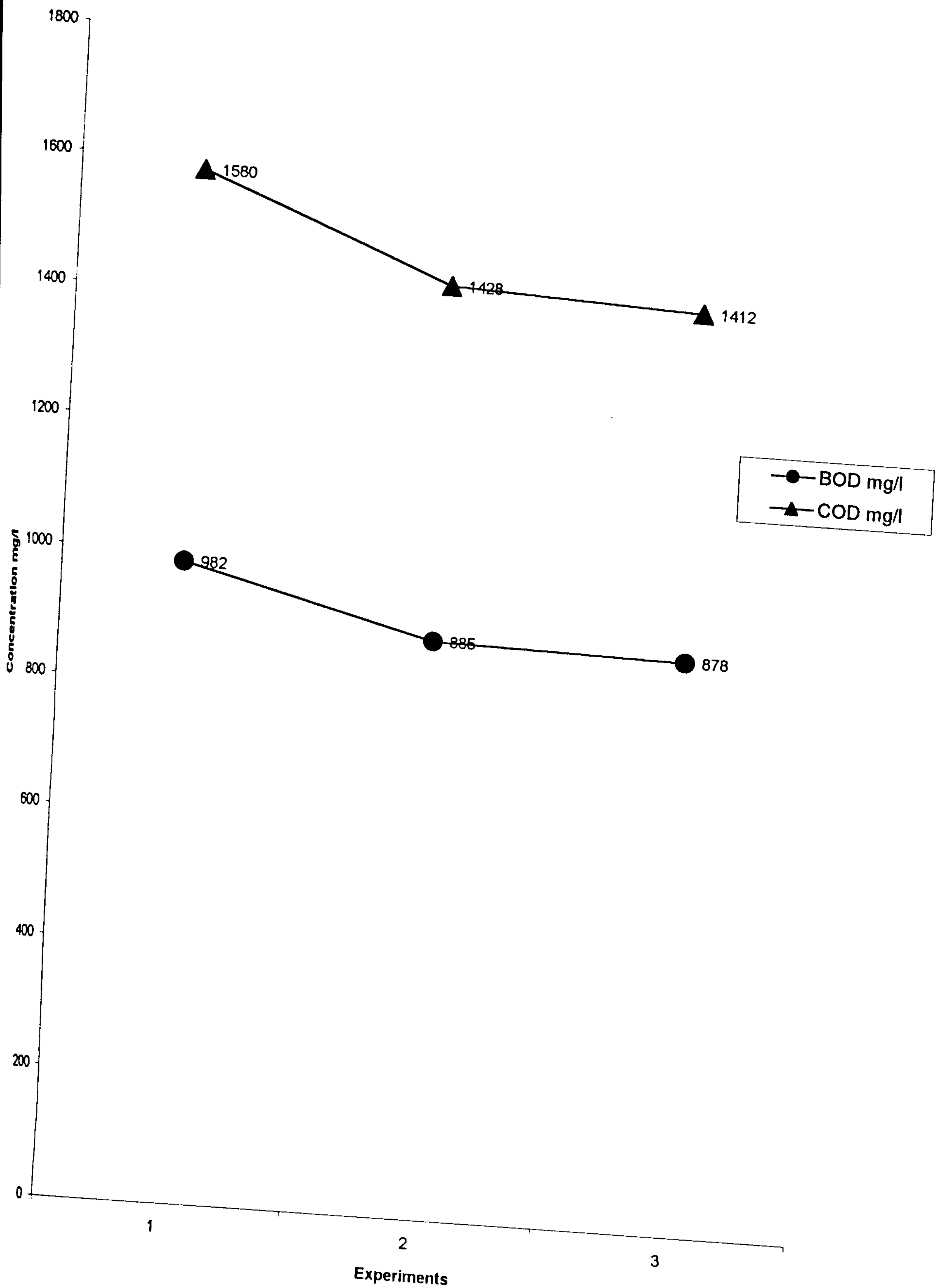
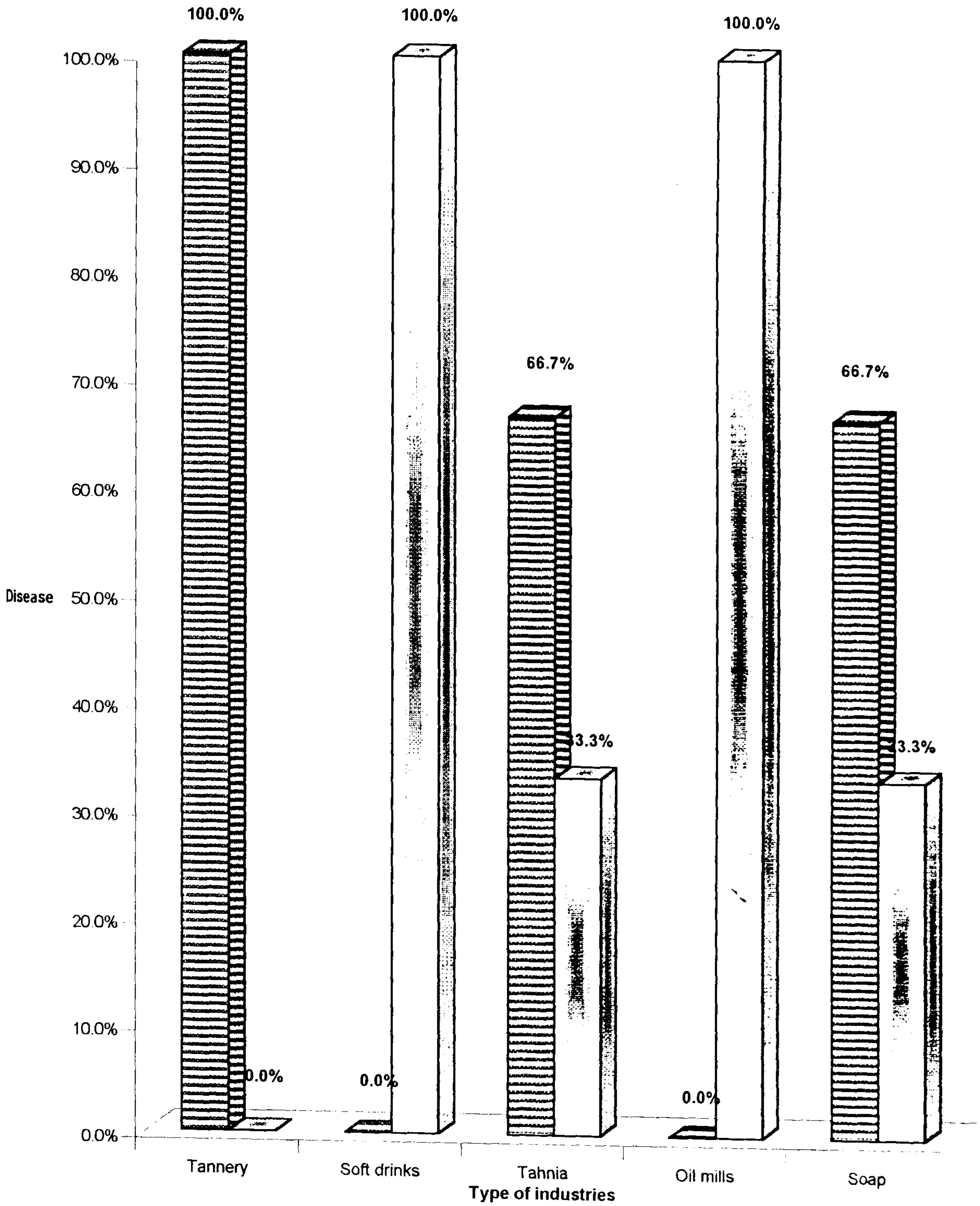


Fig (17): Relationship between prevalent diseases and industries among the industry's workers include in the study



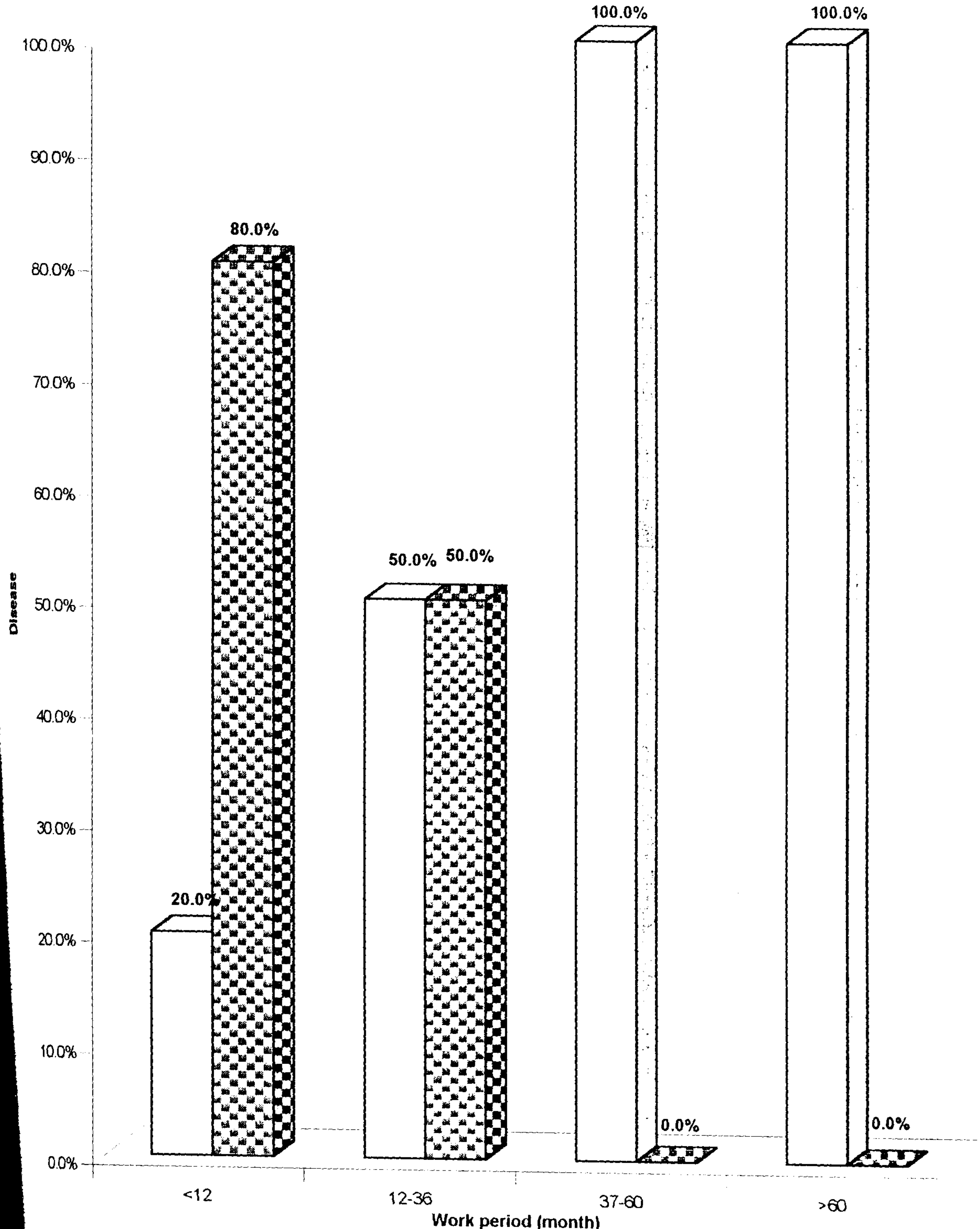
The observed relationship between type of industries and the disease was statistically non-significant at 95% level (P = 0.155). There is no relationship observed between education level and the disease (P = 0.23).

Direct relationship observed between percentage of the disease and the work period among the workers of the industries included in the study. Table (21), Fig (18). The observed relationship is statistically non-significant at 95% level (P = 0.187).

Table (21): The relationship between disease and work period among workers of the industries included in the study.

Work period (month)	**Disease**	
	Yes number (%)	No number (%)
<12	1 (20)	4 (80)
12 – 36	2 (50)	2 (50)
37 – 60	2 (100)	0 (0)
>60	1 (100)	0 (0)

Fig (18): The relationship between disease and work period among the workers of industries included in the study



There is no relationship observed between Age and disease (P = 0.465).

4.2 Pollution Load:

In Omdurman there is no municipal treatment plant, from which to obtain the total pollution load of industrial activities. The analysis carried during this study for five different types of industries so as to reflect the total load of pollution in the area.

4.2.1 Industrial Waste Waters :

The wastes vary greatly in their physical and chemical properties. The contribution of each of the studied industries to the total pollution load is clearly represented in Tables (22,23) where the Elmadeh oil, Yareem, National industries, and Tawfig soap discharge large amount of wastes on the land.

In order to have an idea about heavy metals chromium in this study refer to Table (24), from the Table it is clear that chromium exceeds the level, so there is metal pollution.

The pollution load was obtained from the lab tests carried on the industrial liquid waste disposed. The characteristics and concentrations of the waste are reflected in the form of flow rates Fig. (19) and (20), in these figures the large amounts of waste waters are mainly from Nile soft Drinks factory, Tagoug Soap and Tawfig soap, so their pollution effects are very high. Most of the BOD as seen in Fig. (21), is coming from the Nile soft drinks, Suliman tannery and National industries.

Table (22): Contribution of selected industries effluents to the total pollution load

Industrial unit	Q*	BOD5	COD	O&G	T.S	D.S	S.S
	(m^3/d)	(Kg/d)	(Kg/d)	(Kg/d)	(Kg/d)	(Kg/d)	(Kg/d)
Elmadeh Oil Mills Co .LTD	19.96	19.2	31.5	200.4	3489.3	1863.7	1652.7
Babiker Oil Mills	15.45	11.6	18.9	95.3	1705.6	956	869.6
Suliman Tannery	34.47	31.1	57.9		1187.2	315.7	871.5
Thiga Soft Drinks Bottling Factory	451.01	165.6	201.3		505.3	372	133.3
Tagoug Soap Factory	117.44	10	13.9	162.8	1162	630	532
Tawfig Soap Factory	40	13.6	19.5	17.7	1766.7	954	812.7
National Industries Sweetes and Biscuits	22	19.6	31.9		2940	1630	1310
Yareem Tahnia Factory	23	18.3	29.5		2980.7	1675.3	1485.3
Total	**723.33**	**289**	**404.4**	**476.2**	**15737**	**8396.7**	**7667.1**

Table (23): Percentage contribution of each industry effluents to the total pollution load

Industrial unit	**Q* (m3/d)**	**BOD5 (Kg/d)**	**COD (Kg/d)**	**O&G (Kg/d)**	**T.S (Kg/d)**	**D.S (Kg/d)**	**S.S (Kg/d)**
Elmadeh Oil Mills Co .LTD	2.76%	6.64%	7.79%	42.08%	22.17%	22.20%	21.56%
Babiker Oil Mills	2.14%	4.01%	4.67%	20.01%	10.84%	11.39%	11.34%
Suliman Tannery	4.77%	10.76%	14.32%	0.00%	7.54%	3.76%	11.37%
Nile Soft Drinks Bottling Factory	62.35%	57.30%	49.78%	0.00%	3.21%	4.43%	1.74%
Tagoug Soap Factory	16.24%	3.46%	3.44%	34.19%	7.38%	7.50%	6.94%
Tawfig Soap Factory	5.53%	4.71%	4.82%	3.72%	11.23%	11.36%	10.60%
National Industries Sweetes and Biscuits	3.04%	6.78%	7.89%	0.00%	18.68%	19.41%	17.09%
Yareem Tahnia Factory	3.18%	6.33%	7.29%	0.00%	18.94%	19.95%	19.37%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Q*: Flow rate
d: Day

Fig. (19): Studied Indutries Wastewater (Percentage) Flow Rates

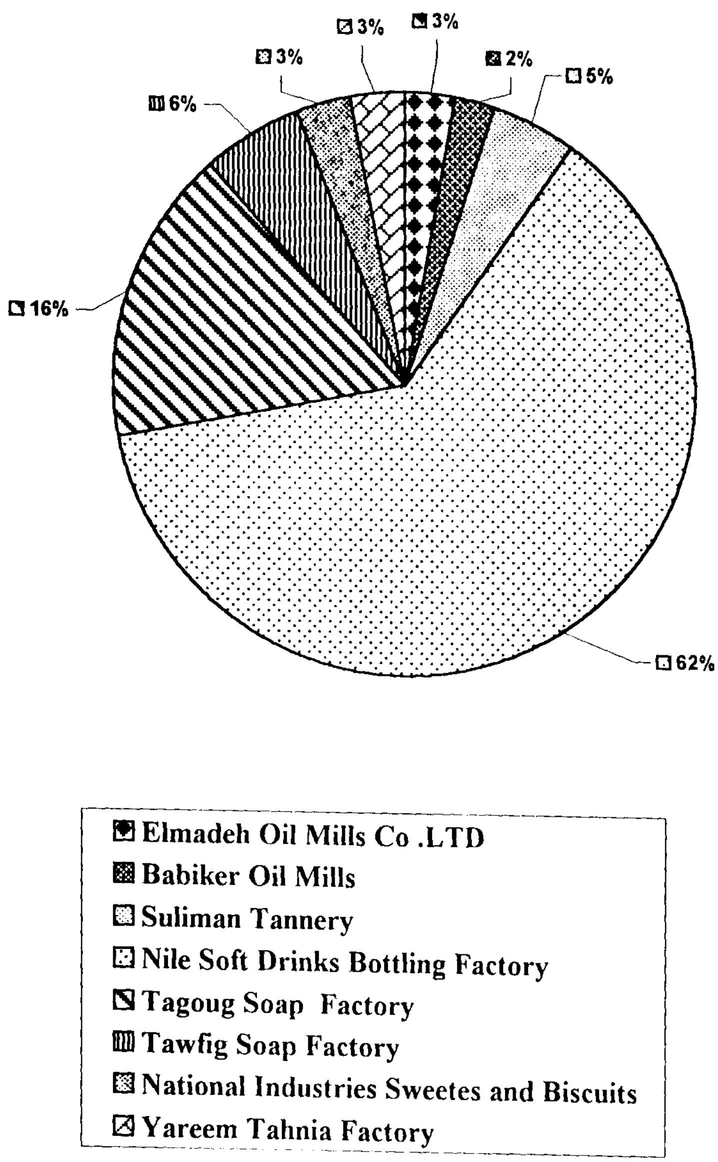


Fig. (20): Industrial Wastewater flow Rates(Q*)

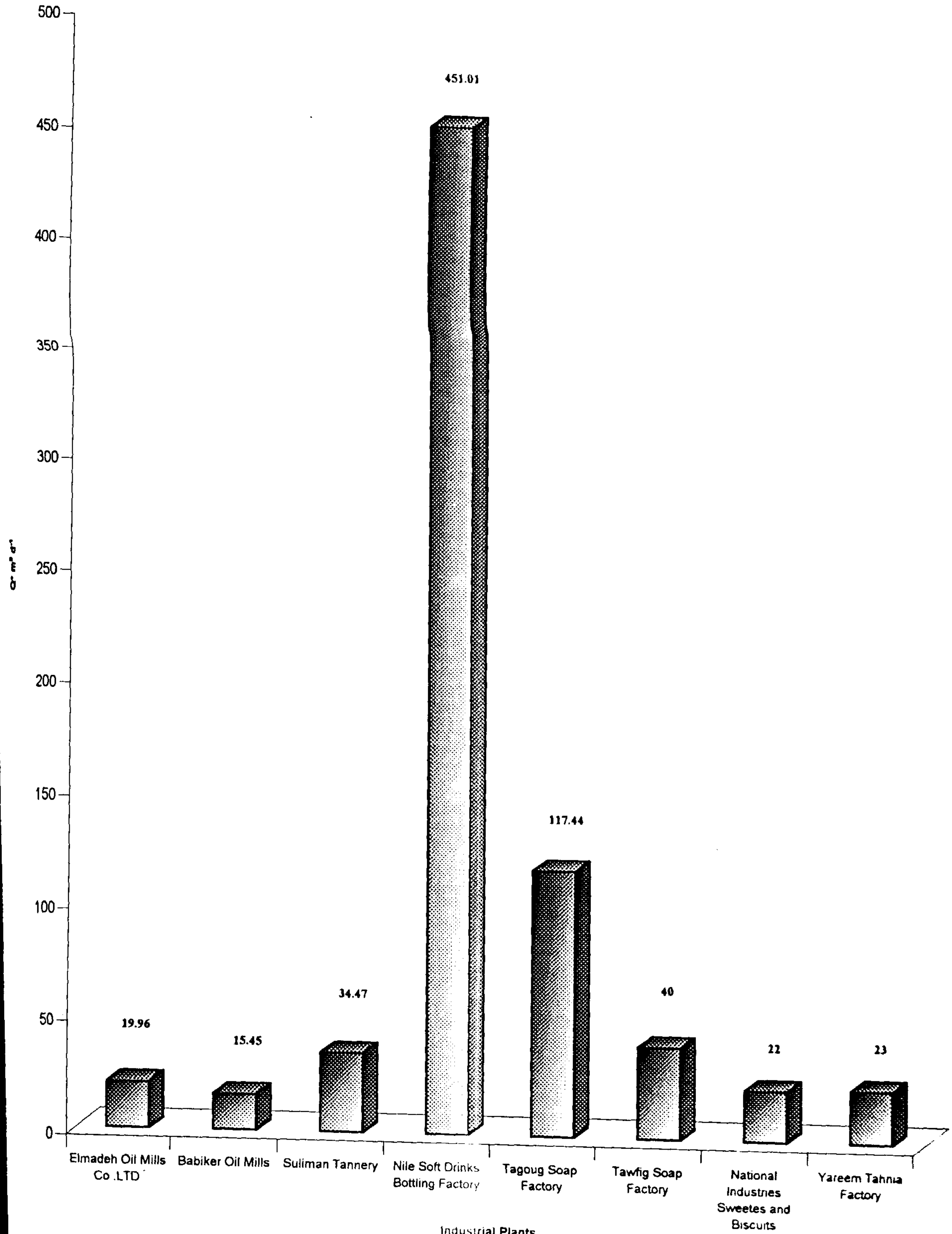
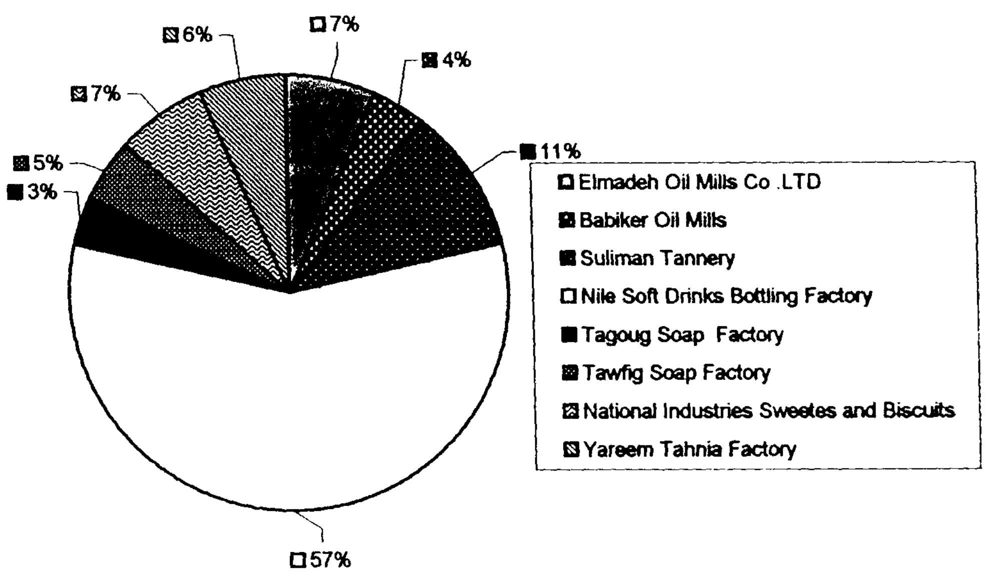


Fig. (21) : Industerial Liquid Wastewater Percentage (BOD)



The considerable contribution is from Nile Soft Drinks, Suliman tannery, National Industries, Yaareem and Elmadeh Oil. The total COD load could be clearly seen in Fig. (22).

In Fig. (23) oil and grease could be seen. It is disposed of from Elmadeh oil, Tagoug soap and Babiker oil that practice (land) disposal.

The total solids of industrial waste water are shown in Fig. (24).

In this case most of the solids are liberated from Elmadeh oil, and the Yareem factory. Furthermore, when looking at the studied industries Table (25) and their combined wastes, it was found that the industries practice disposal on land, Table (26), (27) and (28). In table (22) high BOD amounts are disposed of the Nile soft Drinks and Suliman Tannery. In Table (27) a wide range in solids can be observed and all the included industries are polluting the environment according to Khartoum North Local order of 1971. This because solids should not (in order) exceeds 800 mg/L (S.S), prior to disposal for any treatment.

In Table (26) all the industries disposes wastes on land (open area) without treatment.

High COD values are clear as shown in Table (26). All industries in Tablec (27,28) generate waste water of high amounts of Solids and high temperatures as in the case of soap factories. These practices lead to land pollution.

Fig. (22) : Industrial Wastewater Percentage COD

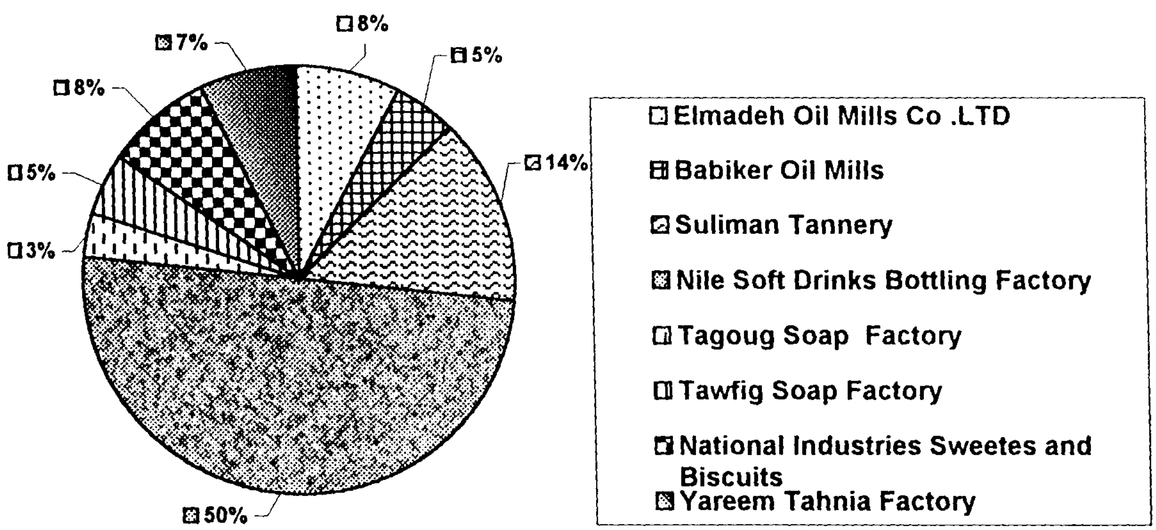


Fig.(23): Industrial Liquid Waste Oil & grease (Persentage)

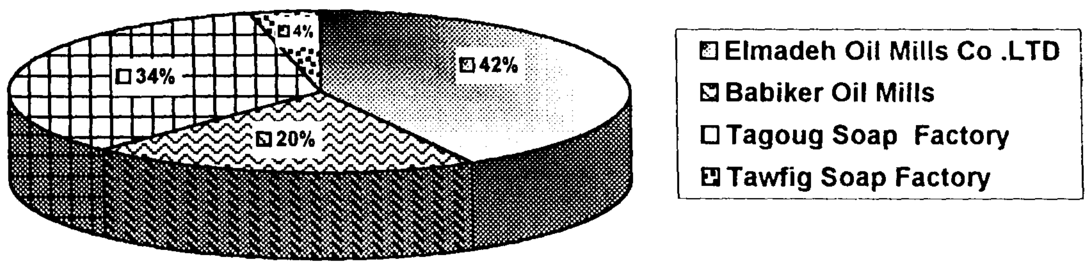


Fig.(24) : Total Solids of Industrial Wastewater (Persentage)

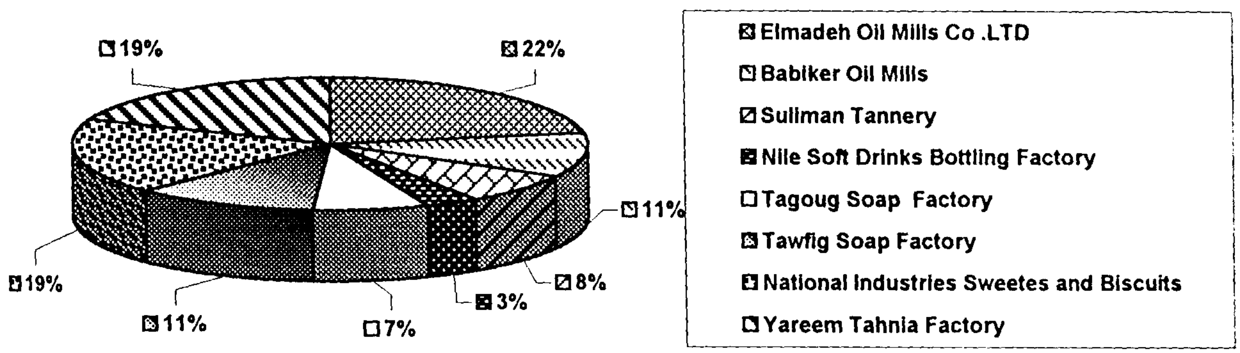


Table (24): Heavy metal (chromium) of wastewater disposed on the land

Industrial Unit	Cr mg/l	Average mg/l
Suliman Tannery	5.8 5.4 6.5	5.9

Table (25): Percentage of the studied industries to total subgroups

Industrial Unit	Percentage to total sub-group
1-Elmadeh Oil Mills Co. LTD	7.1
2-Babiker Oil Mills	7.1
3-Suliman Tannery	33.3
4-Nile Soft Drinks Bottling Factory	100
5-Tagoug Soap Factory	7.7
6-Tawfig Soap Factory	7.7
7-National Industries	7.7
8-Yareem Tahnia Factory	7.7

Table (26): Organic constituents of wastewaters disposed on the land

Industrial unit	BOD range mg/l	COD range mg/l	O&G Range mg/l
1-Elmadeh Oil Mills Co. LTD	896-996	1472-1936	6847-13189
2-Babiker Oil Mills	953-978	1563-1594	7932-7947
3-Suliman Tannery	962-984	1791-1821	
4-Nile Soft Drinks Bottling Factory	89.1-186	109.6-214	
5-Tagoug Soap Factory	661-686	918-941	3780-17930
6-Tawfig Soap Factory	675-684	968-985	860-907
7-National Industries Sweets and Biscuits	972-986	1588-1605	
8-Yareem Tahnia Factory	878-982	1412-1580	

Table (27): Solids content of wastewaters disposed on land

Industrial unit	T.S. Range(mg/l)	D.S. Range(mg/l)	S.S. Range(mg/l)
1-Elmadeh Oil Mills Co. Ltd	167100-180300	88500-94200	78600-86100
2-Babiker Oil Mills	140300-144100	78600-80700	61700-92300
3-Suliman Tannery	31400-42500	7800-11700	23600-30800
4-Nile Soft Drinks Bottling Factory	270-590	200-410	70-180
5-Tagoug Soap Factory	79500-81500	39800-43400	31600-38100
6-Tawfig Soap Factory	85100-92400	45200-49600	39200-42800
7-National Industries Sweetes and Biscuits	144500-150800	79700-82500	63400-68300
8-Yareem Tahnia Factory	141500-157200	80800-87900	60700-69300

Table (28): Quality of waste disposed by industries on land (temperature and pH)

Industrial unit	Temperature range (°c)	pH range
1-Elmadeh Oil Mills Co. LTD	40-51	11.7-12.8
2-Babiker Oil Mills	40-45	9.4-10.1
3-Suliman Tannery	22-25	11.8-12.1
4-Nile Soft Drinks Bottling Factory	22-35	8.4-8.8
5-Tagoug Soap Factory	62-76	10.7-12.8
6-Tawfig Soap Factory	47-55	10.4-12.6
7-National Industries Sweets and Biscuits	20-24	9.6-9.8
8-Yareem Tahnia Factory	23-25	9.6-10.3

Chapter Five 5

Discussion

Chapter Five

Discussion

The general practice in Sudan, is to dispose of untreated industrial wastes on land, water & to the open atmosphere. The exception is in few areas.

5.1 Studied Industries:

Five types of industries were selected to represent the operating industries in Omdurman area.

All the study area has no municipal treatment plant. There is no storm drainage facilities. Since all industries in Omdurman do not treat their wastes. Therefore, the environment would be affected adversely.

In the case of legislations, the area has specified order & standards to control the waste disposal into water, land, & air.

In the studied industries, the total investment capital is about 1226 million dinar according to the 2000 prices. They employ 547 persons & only 8.4% of them are involved in waste handling.

The total fuel consumed in auto-generating electrical energy is about 3933 galon/d Table (9).

Raw materials as *well as wastes* vary in nature and quantity for each sub-sector of industry considered. The material input and output is clearly reflected in Figs (5, 9, 11, 12, 14, 15).

The produced wastes are disposed of on areas allotted by the municipality. Numerous outdoor dumping sites allover the industrial area, plates (5,6,7) are found. These are constituting a health hazard and negative aesthetic value.

Plate (5): Illegal dumping site at the middle of industrial Area.

Plate (6): Another illegal dumping site not far from residential area (New Omdurman Hara 1).

All industries in Omdurman are, use private wastes dumps. The majority of the industrial plants to minimize costs, employ waste handling workers who are not educated enough to protect the environment. According to these practices which can not be controlled,these workers would not carry the wastes to the areas allotted by municipality, so wastes concentrate out doors and it's causes several effects on the environment.

5.2 Industrial Wastes:

According to pollutant type the Khartoum North local order (1971) for waste disposal, is used in this study. In order to reach a better representation the industries were grouped to:

5.2.1 Industries practice land waste disposal , and these are 100% of studied industries.

According to Article 26 of Khartoum North local order. The allowed (BOD5 & S.S) contents of the disposed wastes should not exceed 800 mg/L, but nothing is mentioned about the COD. However, from Table (26), the Elmadeh Oil, Babiker Oil, Tannery & Tahnia factories are exceeding the permissible BOD amounts. The wastes of the other group, are characterized by low BOD.

According to Article (26) the suspended solids of waste water disposed on land Table (27). All the factories are exceeding the limits, except the soft drink factory. The COD is very high in all factories, except soft drinks factory. All industries in Table (27) are high polluters.

According to Article 25 of the local order (grease and oil), the oils and soap factories are exceeding the limits.

Articles 23 and 24 of the local order are putting 60°C temperature and 6.5 – 9.0 pH values a limits for disposal. All factories in Table (28) (land disposing units) are not polluting from the article 23 point of view.

The variation in the BOD and COD values Figs (6, 8, 13, 16).

The variation is more clear in soft drinks factory. This variation is mainly due to the uncontrolled waste discharges, variable production efficiencies, variation in raw materials and production process.

The studied factories are surrounded by residential areas. The lack of proper waste disposal has lead to creation of pools. These pools are causing odour problems, harbouring flies, insects, dogs. Thus making problem to the adjacent areas Plate (8).

5.2.2 Industrial Solid Wastes:

The municipality has garbage collection system in the industrial area. The municipality of Omdurman town had allotted two sites for waste disposal , now are surrounded by town extensions (i.e 1 km far from the residential area). Thus creating nuisance and malodour to the adjacent areas. The solid wastes are disposed directly into the open environment plate (9, 10).

5.2.3Gaseous Wastes:

The major source of the gas is combustion of fuel oil and presence of a large number of private generators. All this could affect the atmosphere through the emitted hazards gaseous and particulate plate (11,12).

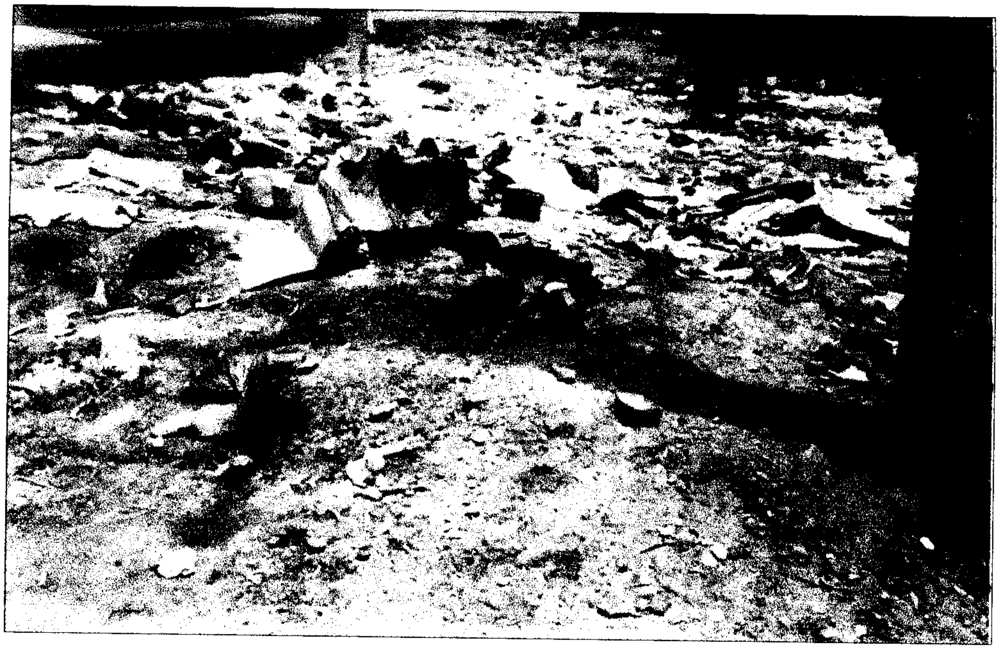


Plate (7): An empty space, facing tawfic soap factory is used as a temporary dumping area.

Plate (8): The next residential area it's about 1 kilometer far from the dumping side.

Plate (9): Solid waste (hair, bottles, carton) from tannery and soft drinks factories.

Plate (10): Empty bottles, for poor people to use for their various purposes.

Table (29): Studied industries waste water physical characteristics

Industrial unit	Physical properties	
	Odour	**Colour**
1- Elmadeh Oil Mills	Aromatic like	Dark brown
2- Babiker Oil Mills	Aromatic like	Dark brown
3- Suliman Tannery	Nasty	Grey
4- Nile soft drinks	Odourless	Colourless
5- Tagoug soap	Aromatic like	Yellowish
6- Tawfig soap	Aromatic like	Yellowish
7- National industries	Odourless	Dark Grey
8- Yareem Tahnia	Odourless	Dark Grey

5.3 Combined Wastes:

Liquid Wastes:

The amounts of wastes discharged per day out of the studied factories are combined to represent the total pollution load, which enters the environment Table (23). It was found that the total liquid waste is 723.3 m^3/d. The physical characteristics of waste are mainly dependent on the raw material used & the production process Table (29).

Heavy Metals:

The waste from tannery factory was analyzed to see the amounts of chromium . According to the Article (31) "Chromium should not exceed 1.0 mg/L". The tested wastes have got 5.9 mg./L amount of chromium Table (24).

The total amount of BOD in the combined wastes was found to be 0.289 t/d which is entering the environment while COD is 0.404 t/d. The total oils on the other hand were found to be 0.476 t/d and the wastes are characterized by a very high total solid contents (15,737 t/d). The amounts of solids is high, because all studied industries are lacked for pretreatment of waste water (i.e sedimentation process). The total dissolved solids is 8.396 t/d while the suspended solids are 7.667 t/d.

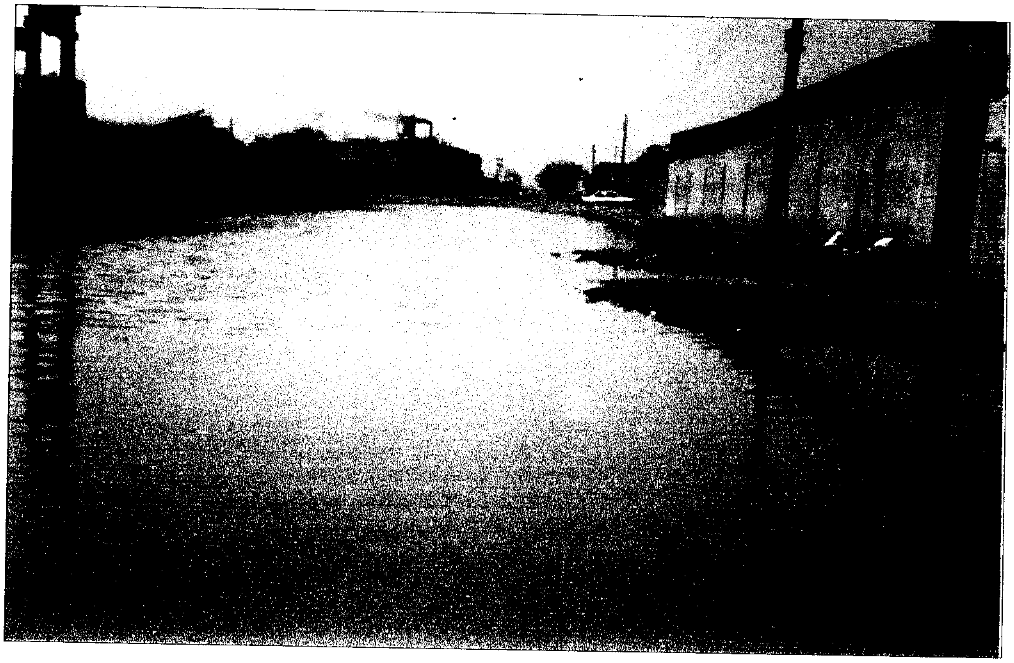


Plate (11): Smoke out of a Relatively Short Chimney and Water is accumulated in the Street of the

Plate (12): Smoke out of a tall stack chimney which polluting the Residential area (Hara 15 Zagalona).

All solids contained and organic contained are discharged on land, Tables (22, 26, 27) and Fig (24).

The major contributor, in the total pollution load is the soft drinks factory which disposes 62.4 % of the total flow rate.

The second factory is Tagoug soap factory (16.2%), followed by the Tawfig soap (5.53%).

On the other hand the soft drinks factory disposes 57.3% of the total biodegradable oxygen (BOD), so it is a major polluting plant. Also 10.8% is from the tannery. The tahnia factories and Elmadeh oil mills, discharge waste of 6.6% of the total BOD and 4.7% and 4.0% are from Tawfig soap and Babiker oil mills respectively and 3.5% is from Tagoug soap factory.

In the case of the chemically oxidizable matter, the soft drinks factory is the highest contributer in the total pollution load (49.8%). Then followed by the tannery (14.3%) and the tahnia, which produces 7.8% of the total COD load. The soap factories and Babiker oil come next.

However, when oil and grease are taken as pollution source. The Elmadeh oil mills factory discharges 42.1% of total load,then tagoug 34.2%, the Babiker oil 20% and lastly is the Tawfig soap factory.

5.3 Waste Handling Workers:

The labourers working in waste handling are the old ones, theyare unqualified. The labourers have neither ability to change their job, nor skilled enough for other job Table (10).

In all factories insurance is provided, which is usually taking from works as deposits. The affected by occupational diseases during the study year are shown in Fig (17). Higher percentage of disease among the workers of Tannery, Thnia, and Soap industries is lower.

5.4 Waste effects:

(i) Land pollution:

The waste when discharged on land; results in odours, pools, as in all studied industries, thus has pool surrounding the residential area like soap factory , plate (13).

The solids such as those burned outside the tannery factory, emit smokes and odours which are nuisance to the adjacent residential areas. The uncontrolled out doors dump harbours rats, flies, dogs and cats as in the case of the tannery factory. Health is also affected by; careless handling and protection for labour is not enough and uncontrolled discharges.

(ii) Air Pollution Effects:

The dusts and particulates enter the atmosphere from all the studied industries due to combustion of fuel oils. Also material damage and property losses, where wastes affects paints, windows, steel works, clothes etc... which mainly due to air pollution.

(iii) Noise Nuisance due to the large *number of private generators and* equipment in industrial areas. Sound environmental management to control the resources and the pollution and this is done by reuses or reducing or recycling of the waste.

Plate (13): Ponds of wastewater flowing out of soap factories not far from the residential area.

Plate (14): Wastewater is used for brick making.

Chapter Six

6

Conclusion & Recommendations

Chapter Six

Conclusions & Recommendation

1- The absence of municipal sewage systems in Omdurman encouraged the individual uncontrolled practices of waste disposal.
2- All industrial units don't usually implement industrial waste treatment practices.
3- The workers at waste disposal must be protected by proper training and should be provided with equipment suited to the job.
4- The environment is polluted due to the relatively high pollution loads of industrial wastes disposed on land and air.
5- The sites allotted by the municipal authorities for waste disposal, not far from residential areas.
6- Soap stock from soap factories is disposed in the pond near the residential area. The people who lives in these area are used it. As to soap stock some people are collecting it from the last manhole using it to produce a low class laundry soap.
7- Effluents from tannery have very nasty odour because of the skin and hides fermentation and waste handling worker are affected from these odour.
8- It is clear that there is air pollution since the highest of the chimneys is very low, plate (11).
9- Waste water from soft drinks factory is disposed in the open area near the place that allotted by municipal authorities. Some of the inhabitants of the area are using this waste water for brick making plate (14).
10- All the above drawbacks are due to the lack of proper waste management system, like waste minimization, recycling and pretreatment plants.
11- There is a strong relationship between the high prevalence of occupational disease and period of working.

Recommendations

1- Establishment of local waste quality disposal standard, for the various types of wastes and enforcement of these legislation and standards.

2- The factories must install suitable flow meters. This will provide a better knowledge of the water consumption and volume of effluent discharged by the area.

3- Construct a sewage system in the area. Construct a pre-treatment unit in each factory followed by a central treatment plant.

4- Construct similar factories in specific area for reducing waste water collection and disposal (proper planning) problems.

5- Implementing environmental impact assessment studies for all factories.

6- Cooperation between municipal authorities and state and the factories administration is required to solve the problem of waste water.

7- Develop the awareness of waste handlers regarding the affects of industrial wastes on health and environment through health education.

8- Site allotted by municipal authorities for disposing of waste water should be allocated based on scientific knowledge to avoid polluting the environment.

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Appendices

Annex I

Liquid wastes

The Environmental Health Act 1975 Controls the important aspects of water Pollution but only in a general manner.

The health authority may allow the disposal of treated sewage water and industrial refuse in the sewers subject to the following conditions:

(a) if the sewer is a canal used for treated sewage water only or mixed canal used for treated sewage or industrial refuse together with natural water for irrigation of agricultural land :

i. the biochemical oxygen demand shall be less than 20 parts in a million parts by weight of water.
ii. the proportion of the suspended matter shall be less than 30 parts in every million parts by weight of water.
iii. there shall be no concentrated chemical matter in the treated water, affecting human or animal health or causing damage to crops.
iv. the health authority shall take all measures to prevent human beings or animals from using treated water for a purpose other than irrigation of agricultural land.

(b) if the sewer is an evaporation basin made for that purpose :

i. the site of such basin shall be far from the residential area in the village or town.
ii. the basin shall be constructed in such a manner so as to prevent infiltration.
iii. the sewers in the basin shall be designed in such manner as to prevent mosquito breeding.

بسم الله الرحمن الرحيم

وزارة الصحة

مشروع قانون صحة البيئة

لا بأحكام دستور جمهورية السودان لسنة ١٩٩٨ أجاز المجلس الوطني ووقع رئيس الجمهورية
انون
تي نصه :-

الفصل الأول

احكام تمهيدية

اسم القانون وبدءا العمل به

يسمي هذا القانون قانون صحة البيئة لسنة ١٩٩٩م ويعمل به من تاريخ التوقيع عليه.

تفسير

في هذا القانون مالم يقتض السياق معني اخر :-

وث بوساطة الإنسان . يقصد به التلوث الذي نتج من أنشطة الإنسان في السكن والأسواق والمنشآت وحرق الأوساخ وتوليد الكهرباء وغيره.

ث الهواء . يقصد به تلوث الهواء الخارجي بأي مادة غريبة لدرجة تسبب الأضرار بصحة البيئة والممتلكات ويشمل التلوث العوامل الطبيعية كالعواصف والبراكين.

ع الري يقصد بها الترع التي تستخدم في ري الأراضي الزراعية وتستمد مياهها مباشرة من نهر أو قناة أو خزان ولا تشمل ترع الري المختلطة أو المعالجة التي تحمل الفضلات السائلة من مخلفات المجاري.

لطة الصحية المختصة يقصد بها الجهة الإدارية التنفيذية المسئولة عن ادارة الخدمات الطبية والصحية وخدمات صحة البيئة علي كافة المستويات المحلية الولائية والاتحادية بحسب الحال.

باني يقصد بها المباني التي يتخذها الإنسان للسكن أو العمل أو الترفيه أو غيره.

لس الصحة الاتحادي . يقصد به مجلس الصحة العامة الاتحادي المنشا بموجب احكام قانون الصحة العامة لسنة ١٩٩٧.

لس الصحة بالولاية . يقصد به مجلس الصحة العامة بالولاية المنشا بموجب احكام قانون الصحة العامة لسنة ١٩٩٧.

ه الشرب . يقصد بها المياه الصالحة لاستعمال الإنسان والحيوان.

زارة . يقصد بها وزارة الصحة الاتحادية

زير . يقصد به وزير الصحة الاتحادي.

الفصل الثاني
لجان صحة البيئة
لجنة صحة البيئة الاتحادية

(١) تنشأ لجنة تسمي لجنة صحة البيئة الاتحادية
(٢) تشكل اللجنة المذكورة في البند (١) علي الوجه الأتي:-

(أ) مدير عام الطب الوقائي	رئيسا
(ب) ممثل ديوان الحكم الاتحادي	عضوا
(ج) ممثل وزارة الصناعة	"
(د) ممثل وزارة العدل	"
(ه) ممثل وزارة الزراعة والموارد الطبيعية	"
(و) ممثل الثروة الحيوانية	"
(ز) رئيس ادارة الصحة المهنية بالوزارة	"
(ح) مهندس متخصص في هندسة صحة البيئة	"
(ط) مدير ادارة صحة البيئة بالوزارة	"

اختصاصات لجنة صحة البيئة الاتحادية

٧- تختص لجنة صحة البيئة الاتحادية بالأتي:-

(أ) رفع توصيات للوزير ولمجلس الصحة الاتحادي بشأن السياسات اللازمة لحماية البيئة من جميع الأضرار أو المخاطر الصحية ولرفع مستوي صحة البيئة.

(ب) رفع التوصيات للوزير ولمجلس الصحة الاتحادي بشأن المواصفات والمعايير والمستويات الخاصة بجميع المباني والمرافق والمنشآت والتركيبات والمعدات والأدوات فيما يتعلق بصحة البيئة.

(ج) رفع التوصيات للوزير فيما يتعلق بإصدار اللوائح اللازمة لتنفيذ احكام هذا القانون.

(ت) التوصية للوزير لوضع الخطط والسياسات الاتحادية في مجال صحة البيئة والعلاقات الخارجية.

(هـ) تنسيق خطط صحة البيئة وفق السياسة العامة.

حظر التصديق بالمصانع وغيرها

٨- لا يجوز لأي جهة إصدار أي تصديق أو ترخيص بقيام مصنع أو منشأة أو مرفقا أي نشاط قد يؤثر علي صحة البيئة.

الفصل الثالث

إزالة ما يضر بصحة البيئة

٩- (١) يجب علي أي جهة إزالة العوامل التي تضر بصحة البيئة متى ما طلبت اليها أي جهة مختصة ذلك.

(٢) لدي ممارسة السلطة الصحية المختصة لسلطاتها وفق احكام البند (١) يجب عليها تنفيذ التوجيهات التي تصدر أليها من الأجهزة الولائية والاتحادية المختصة ويجب عليها عدم المساس بأي نشاط يتعلق بتلك الأجهزة.

الفصل الثاني
لجان صحة البيئة
لجنة صحة البيئة الاتحادية

(١) تنشأ لجنة تسمي لجنة صحة البيئة الاتحادية
(٢) تشكل اللجنة المذكورة في البند (١) علي الوجه الأتي:-
(أ) مدير عام الطب الوقائي رئيسا
(ب) ممثل ديوان الحكم الاتحادي عضوا
(ج) ممثل وزارة الصناعة ''
(د) ممثل وزارة العدل ''
(ه) ممثل وزارة الزراعة والموارد الطبيعية ''
(و) ممثل الثروة الحيوانية ''
(ز) رئيس ادارة الصحة المهنية بالوزارة ''
(ح) مهندس متخصص في هندسة صحة البيئة ''
(ط) مدير ادارة صحة البيئة بالوزارة ''

اختصاصات لجنة صحة البيئة الاتحادية

٧- تختص لجنة صحة البيئة الاتحادية بالأتي:-
(أ) رفع توصيات للوزير ولمجلس الصحة الاتحادي بشأن السياسات اللازمة لحماية البيئة من جميع الأضرار أو المخاطر الصحية ولرفع مستوي صحة البيئة.
(ب) رفع التوصيات للوزير ولمجلس الصحة الاتحادي بشأن المواصفات والمعايير والمستويات الخاصة بجميع المباني والمرافق والمنشآت والتركيبات والمعدات والأدوات فيما يتعلق بصحة البيئة.
(ج) رفع التوصيات للوزير فيما يتعلق بإصدار اللوائح اللازمة لتنفيذ احكام هذا القانون.
(ت) التوصية للوزير لوضع الخطط والسياسات الاتحادية في مجال صحة البيئة والعلاقات الخارجية.
(هـ) تنسيق خطط صحة البيئة وفق السياسة العامة.

حظر التصديق بالمصانع وغيرها

٨- لا يجوز لأي جهة إصدار أي تصديق أو ترخيص بقيام مصنع أو منشأة أو مرفقا أي نشاط قد يؤثر علي صحة البيئة.

الفصل الثالث

إزالة ما يضر بصحة البيئة

٩- (١) يجب علي أي جهة إزالة العوامل التي تضر بصحة البيئة متي ما طلبت اليها أي جهة مختصة ذلك.
(٢) لدي ممارسة السلطة الصحية المختصة لسلطاتها وفق احكام البند (١) يجب عليها تنفيذ التوجيهات التي تصدر أليها من الأجهزة الولائية والاتحادية المختصة ويجب عليها عدم المساس بأي نشاط يتعلق بتلك الأجهزة.

الفصل الرابع

المياه

منع تلوث المياه

١٠- لا يجوز لأي شخص ان يصرف أو يلقي أو يعمل على تصريف أو إلقاء أي مواد سواء كانت صلبة او سائلة أو غازية علي مصادر مياه الشرب الصالحة لاستعمال الإنسان والحيوان داخل مجاري الأنهار او روافدها أو الحفائر أو الآبار أو البحر مما يضر او يحتمل ان يضر بصحة الأنسان الحيوان أو استعمال الإنسان للمياه في الأغراض الأخرى ودون الإخلال بعموم ما تقدم لا يجوز له ان يلقي في مصادر مياه الشرب المذكورة في صدر هذه المادة

(أ) أي فضلات أو نفايات ناتجة عن عمليات صناعية سواء كانت صلبة أو سائلة أو غازية معالجة أو غير معالجة.

(ب) أي مواد كيماوية صناعية أو زراعية سواء كانت معالجة أو غير معالجة.

(ج) أي مياه مجاري خام ناتجة عن دورات المياه والمطابخ والحمامات والمراحيض أو مياه مجاري معالجة.

(د) أي مخلفات او غير مرغوب فيها سواء كانت معالجة او غير معالجة ناتجة عن استعمال الإنسان في السكن أو المصنع أو أي مكان أخر .

(هـ) أي حيوانات ميتة أو روث بها يم بالقرب من أي بحر او نهر او رافد يصب في أي نهر او أي حفير او بركة طبيعية او بئر او اي ترعة أو داخل أي من المصادر انفة الذكر.

مراقبة مياه الشرب

١١- يجب علي السلطات الصحية المختصة :-

(أ) القيام بمراقبة مصادر مياه الشرب الخاصة المملوكة للاستعمال الخاص والعامة التي تشمل الأنهار والبحيرات والقنوات والينابيع ومجاري الأمطار والسيول والحفائر والآبار الموجودة علي الأرض عامة ومشاريع مياه الشرب واخذ عينات من مائها بصورة منتظمة لتحليلها للتأكد من صلاحيتها وخلوها من التلوث الناجم عن القاذورات والنفايات والقمامة.

(ب) تفتيش شبكات المياه أو أي مصادر أخرى بالمدن والأرياف بغرض ضمان توصيل المياه للمواطنين دون تلوث.

(ج) القيام بالكشف الطبي الدوري علي العاملين في مصادر أو شبكات أو إمدادات مياه الشرب لضمان خلوهم من أي أمراض معدية يحتمل ان تنتشر بوساطة الماء.

(ح) العمل علي تنقية مصادر المياه التي تتعرض للتلوث حتى تكون صالحة للاستعمال.

شروط حفظ وامداد مياه الشرب

٩-(١) يجب علي كل شخص أو جهة تقوم بحفظ أو بإمداد الجمهور بمياه الشرب سواء في القطاع الخاص أو القطاع العام مراعاة الشروط الصحية ومعايير الصلاحية التي يقررها الوزير من وقت لاخر.

(٢) مع عدم الإخلال بعموم احكام البند (١) لا يجوز لأي شخص أو جهة في القطاع العام أو القطاع الخاص ان:-

(أ) يمد الجمهور بمياه الشرب قبل تحليلها بوساطة الجهة الفنية التي تحددها الوزارة واستلام شهادة بصلاحيتها منها.

(ب) يمد الجمهور بمياه شرب بها أي مواد صلبة أو سائلة أو غازية أو مشعة يحتمل ان تضر بصحة الإنسان.

(ج) يشيد مساكن أو معسكرات أو متنزهات أو مراعي أو مزارع بالقرب من قطعة الأرض المخصصة لتجميع مياه الأمطار أو بالقرب من الروافد التي تغذيها بمياه الشرب أو تخرج منها لتغذية الحفائر أو المشروعات الهندسية الخاصة بمياه الشرب.

(خ) يستخدم أي عامل ألا بعد الكشف الطبي عليه والتأكد من خلوه من أي أمراض معدية.

الرقابة ضد أوبئة مياه الشرب

١٢- يجب علي السلطة الصحية المختصة في حالة ظهور مرض وبائي أو يحتمل ان تسببه مياه الشرب ان تقوم بالإجراءات الوقائية الاتية:-

(أ) اخذ عينات من مصادر مياه الشرب للتحليل الباكتريولوجي والقيام بمعالجة مصادر المياه لتطهيرها ومراقبة سير تطور الوباء

(ب) في حالة التأكد من وجود تلوث لمصادر المياه إصدار الأمر بقفل المصدر وحظر استعماله والاستمرار في المعالجة واخذ العينات حتى تثبت نتيجة التحليل زوال تلوث المصدر.

(ج) الكشف علي جميع العاملين في المصدر الملوث وفي حالة اكتشاف ان ايا من العاملين يحمل ميكروب المرض المسبب للتلوث إصدار الأمر بابعاده عنه.

تصريف المجاري والفضلات الصناعية السائلة

١١-لا يجوز للسلطات الصحية المختصة ان تسمح بتصريف مياه المجاري المعالجة أو الفضلات الصناعية السائلة المعالجة في المصارف إلا وفقا للشروط الآتية:-

(أ) إذا كان المصرف ترعة تستخدم فيها مياه المجاري المعالجة وحدها أو ترعة مختلطة تستعمل فيها مياه المجارى المعالجة أو الفضلات مع المياه الطبيعية لري الأراضي الزراعية فحسب ان:-

(أولا) تكون نسبة احتياج الأكسجين البيوكيماوي التي تستهلكها مياه المصرف خلال خمسة ايام في درجة

حرارة تبلغ ٢٠ درجة مئوية اقل من عشرين مليجرام في كل لتر من الماء المصرف .

(ثانيا) تكون نسبة المواد العالقة اقل من ثلاثين ملجرام في لتر من الماء المصرف.

(ثالثا) لا توجد بالمياه المعالجة أي مواد كيمتوية أو مشعة بتركيز يؤثر علي صحة الإنسان أو الحيوان أو النبات.

(رابعا) تقوم السلطات الصحية بجميع الإجراءات لمنع الإنسان.
أو الحيوان من استعمال المياه المعالجة لأي.
غرض خلاف ري الأرض الزراعية

(ب) إذا كان المصرف حوضا للتبخير ومخصصا لهذا الغرض ان :-

(اولا) يبعد موقع الحوض من المنطقة السكنية في القرية أو المدينة بالمسافة التي تحددها اللوائح.

(ثانيا) يشيد الحوض بطريقة هندسية تمنع التسرب.

(ثالثا) يتم تصميم دورات الصرف في الحوض بطريقة تنع توالد الناموس والذباب.

الفصل الخامس

تلوث الهواء

مواقع الصناعات

١٢- تحدد السلطات الصحية المختصة علي مواقع الصناعات المختلفة والمنشات التي يجوز ان تسبب تلوث الهواء بأي مادة غريبة لدرجة تسبب ضرر لصحة البيئة أو الممتلكات وتقوم بمراقبة مايلي:-

(أ) بعد تلك المواقع عن المدارس والمؤسسات والمرافق العامة والتأكد من عدم وصول الأبخرة والدخان والغازات والنفايات أليها بطريقة تضر بصحة البيئة أو تسبب ضررا أو إزعاج لأي شخص أو تلف الممتلكات.

(ب) البعد المناسب من المنطقة السكنية.

(ج) ان يكون ارتفاع المداخن مناسبا بحيث يسمح بانتشار الأبخرة والدخان والغازات وعدم تركيزها.

(د) ان تتوافر في المصانع أجهزة امتصاص الغازات والنفايات الصغيرة والحد من تركيزها.

(هـ) حظر استعمال المركبات التي تفرز الأدخنة بطريقة مستمرة ومركزة.

أماكن حرق الأوساخ والكمائن

١٣-تحدد السلطات الصحية المختصة أماكن حرق الأوساخ والنفايات والقمامة والكمائن وغيرها من الأماكن المعدة للحرق علي ان تكون الأماكن علي بعد كيلومترين علي الأقل من أي منطقة سكنية أو لا يسبب الحرق ضرر أو إزعاج للمواطنين.

منع تلوث الهواء

١٤- (١) يجوز للسلطة الصحية المختصة اتخاذ أي إجراءات تراها ضرورية لمنع أي شخص يتسبب في تلوث الهواء بأي أبخرة ااو غازات أو دخان أو نفايا أو غبار أو إشعاع أو بحرق الوقود في المصنع أو مركبة أو فرن أو ماكينات بالتركيز الذي يؤثر علي صحة البيئة.

(٢) يجب علي كل شخص يؤمر بتنفيذ توجيهات وأوامر للسلطات الصحية المختصة لإزالة أي مخالفة لاحكام هذا الفصل ان يزيلها خلال الفترة الزمنية المحددة في التوجيهات أو الأوامر الصادرة أليه.

(٣) يجوز إزالة تلك المخالفة علي نفقة الشخص أو الجهة التي تسبب فيها إذا :-

(أ) فشل الشخص الذي طلب منه أزالتها.

(ب) كانت الإزالة مطلوبة بصفة مستعجلة .

حظر إلقاء النفايات دون تصديق

١٥-(١) لا يجوز لأي شخص ان يصرف أو يلقي أو يعمل علي تصريف أو إلقاء أي مواد سواء كانت صلبة أو سائلة أو أي فضلات أو نفايات سواء كانت صلبة أو سائلة أو أي قمامة أو مواد كيماوية علي أي رض خاصة أو عامة أو دفنها في أي ارض خاصة أو عامة الا إذا حصل علي تصديق بذلك من السلطة لصحية المختصة .

٢) يجب علي السلطة الصحية المختصة قبل إصدار التصديق بموجب احكام البند (١) ان تتأكد من ان صريف أو إلقاء أو دفن المواد في تلك الأرض لن يضر بأي ارض عامة بالبيئة أو يؤثر علي المياه سطحية أو الجوفية أو مياه شرب الإنسان أو الحيوان أو الري في المنطقة أو بالغطاء النباتي للأرض جوز للسلطة الصحية المختصة الاستنارة برأي لجنة صحة البيئة المختصة.

الفصل السادس

احكام عامة

إصدار اللوائح

١٦-يجوز للوزير بالتشاور مع مجلس الصحة الاتحادي ان يصدر اللوائح اللازمة لتنفيذ احكام هذا القانون ومع عدم الإخلال بعموم ما تقدم يجوز ان تنص اللوائح علي الآتي:-

(أ) إجراءات وشروط حماية صحة البيئة من الأضرار التي قد تنشأ نسبة للتطور العلمي والتكنولوجي والاجتماعي والاقتصادي والزراعي والصناعي أو من التلوث بوساطة الإنسان.

(ب) تحديد الأعداد اللازمة من الكوادر الصحية المؤهلة العاملة بالأماكن والمرافق والمؤسسات المختلفة.

(ج) تحديد الحدود القصوى لملوثات البيئة والشروط الخاصة بالالتزام بتلك الحدود.

(د) تحديد المستويات الصحية الدنيا للمباني والمرافق العامة.

(هـ) تحديد المعايير الخاصة بمياه الشرب والشروط الصحية الخاصة بإمدادها ومنع تلوثها.

(و) الإجراءات الخاصة بالرقابة والتفتيش واخذ العينات والتحليل.

العقوبات

١٧- كل من يخالف أيا من احكام المواد ٧،٩،١٠،١٥،١٦ يعاقب عند الإدانة بالسجن لمدة لاتزيد عن ثلاث سنوات أو الغرامة أو العقوبتين معا.

المجلس الوطني ... توقيع

دورة الانعقاد الأول

قانون حماية البيئة لسنة ٢٠٠١

عملاً بأحكام المادة ٩٠ (١) من دستور جمهورية السودان لسنة ١٩٩٨ ، أصدر رئيس الجمهورية وأجاز المجلس الوطني المرسوم المؤقت الآتي نصه :-

الفصل الأول

أحكام تمهيدية .

اسم المرسوم المؤقت وبدء العمل به

١ . يسمي هذا المرسوم المؤقت ، " قانون حماية البيئة لسنة ٢٠٠١م " ويعمل به من تاريخ التوقيع عليه .

إلغاء واستثناء

٢ - يلغي قانون المجلس الأعلى للبيئة والموارد الطبيعية لسنة ١٩٩١ ، علي أن تظل سارية المفعول ، جميع اللوائح والتدابير التي اتخذت بموجبه إلي أن تلغي أو تعدل وفقاً لأحكام هذا القانون .

تفسير

٣ . في هذا القانون ما لم يقتض السياق معني آخر :-

الأمانة العامة يقصد بها الأمانة العامة المجلس الأعلى للبيئة والموارد الطبيعية ، المنشأة بموجب أحكام المادة ٨ (٢) .

الأمين العام يقصد به الشخص المعين بموجب أحكام المادة ٨ (٢) .

البيئة يقصد بها مجموعة النظم الطبيعية بمكوناتها من العناصر الأساسية كالماء والهواء والتربة والنبات والحيوانات والكائنات ، وتشمل أيضاً مجموعة النظم الاجتماعية والثقافية التي يعيش فيها الإنسان والكائنات الأخرى ويستمدون منها قوتهم ويؤدون فيها نشاطهم .

التلوث يقصد به التغيرات التي يحدثها الانسان في البيئة وما ينتج عنها من آثار للإنسان والكائنات الحية من الإزعاج أو الأضرار أو الأمراض أو الوفاة بطريقة مباشرة أو غير مباشرة أو إفساد العناصر الأساسية للبيئة أو الإخلال بأنظمتها السائدة والمعروفة ، ويشمل ذلك تلويث الهواء ،

الماء ، التربة و النباتات .

حماية البيئة	يقصد بها حفظ التوازن الدقيق للبيئة و عدم المساس بهذا التوازن ومنع تلوثها وتدهورها وترشيد الاستغلال حسب طاقة الموارد و عدم التسبب في إبادة أي من الكائنات الحية .
السلطة المختصة	يقصد بها كل أو أي من الأجهزة المختصة بحماية البيئة المنصوص عليها في المادة ١٧ .
المجلس	يقصد به المجلس الأعلي للبيئة و الموارد الطبيعية المنشأ بموجب أحكام المادة ٥ .
المجلس الولائي	يقصد به المجلس الولائي لحماية البيئة المنشأ بموجب أحكام المادة ١٥ .
الموارد الطبيعية	يقصد بها الموارد الطبيعية المتجددة و غير المتجددة .
الوزارة	يقصد بها الوزارة الاتحادية المسئولة عن شئون البيئة .
الوزير	يقصد به الوزير الاتحادي المسئول عن شئون البيئة .

الأهداف البيئية

٤ - تسعي الأجهزة المختصة عند ممارستها لاختصاصاتها أو وضع سياساتها لتحقيق الآتي :-

(أ) حماية البيئة وطهرها وتوازنها الطبيعي والمحافظة علي مكوناتها من العناصر الأساسية ونظمها الاجتماعية والثقافية تحقيقاً للسلامة و التنمية المستدامة لصالح الأجيال .

(ب) ترقية البيئة والاستخدام المرشد المستدام للموارد الطبيعية بغرض تنميتها و المحافظة عليها .

(ج) الربط بين قضايا البيئة والتنمية .

(د) التأكيد علي مسئولية السلطة المختصة عن حماية البيئة و السعي الجاد لتحقيق هذه الحماية .

(هـ) تنشيط دور السلطة المختصة والأجهزة التابعة لها ومنع التراخي و القصور في الأداء .

الفصل الثاني

المجلس

إنشاء المجلس

٥ - (١) ينشأ مجلس يسمى ، " المجلس الأعلى للبيئة والموارد الطبيعية " ، وتكون له الشخصية الاعتبارية .

(٢) يكون مقر المجلس الرئيسي بولاية الخرطوم .

(٣) يكون المجلس تحت إشراف رئيس الجمهورية .

تشكيل المجلس

٦ (١) يشكل المجلس بقرار من مجلس الوزراء برئاسة الوزير وعضوية الوزراء المختصين ومن الأجهزة والهيئات ذات الصلة وعدد من الأعضاء ممن تتوافر فيهم الدراية الكافية والخبرة والاهتمام بشئون البيئة والموارد الطبيعية .

(٢) يكون الأمين العام للمجلس عضواً ومقرراً .

اختصاصات المجلس وسلطاته

٧ - تكون للمجلس الاختصاصات والسلطات الآتية وهي :-

(أ) رسم السياسة العامة بالتنسيق مع الأجهزة المختصة في المسائل الآتية :-

(أولاً) للموارد الطبيعية بما في ذلك حصرها وتنميتها وترشيد سبل استخدامها وإدارتها وحمايتها من التدهور بصورة متكاملة ومتوازنة بما يؤمن العطاء المستدام والمتزايد والمستمر لها .

(ثانياً) لحماية البيئة بوجه عام .

(ب) تنسيق أعمال المجالس الولائية والجهود الرامية إلى حصر موارد البلاد الطبيعية وتقويمها ، وتحديد استخداماتها في الحال والمستقبل ، ورصد المتغيرات التي تطرأ عليها ، وتحديد المناطق المعرضة لأخطار التدهور البيئي كالزحف الصحراوي والتلوث البيئي ، ووضع أسبقيات المسوح والدراسات العامة والمتكاملة لتلك الموارد القومية .

(ج) وضع برنامج اتحادي طويل المدى للاستخدام الأمثل والمتوازن للموارد الطبيعية

وصيانتها والمحافظة علي البيئة ومتابعة تنفيذه بالتنسيق مع الجهات المختصة .

(د) المراجعة الدورية للتشريعات ذات الصلة التأكد من مدي مواكبتها وملاءمتها للمعايير الدولية لتنمية البيئة والموارد الطبيعية واستخدامها وصيانتها والتقدم بتوصيات للجهات المختصة بشأنها .

(هـ) تنسيق جهود الدولة فيما يتعلق بالانضمام للاتفاقيات الخاصة بالبيئة ، وتحديد الجهات المناط بها تنفيذ تلك الاتفاقيات .

(و) تشكيل لجان فنية متخصصة لمعاونته في أداء أعماله .

(ز) العمل علي استقطاب مصادر التمويل الحكومية والشعبية والمحلية والدولية لتنفيذ برامج تنمية الموارد الطبيعية وصيانتها وحماية البيئة بالتعاون مع الجهات المختصة .

(ح) تشجيع البحث العلمي في كافة مجالات البيئة والموارد الطبيعية ودعمه بالتنسيق مع المركز القومي للبحوث والجامعات ومعاهد البحوث المتخصصة .

(ط) وضع خطة اتحادية لترقية الوعي البيئي والاستخدام المستدام للموارد الطبيعية وصيانتها والعمل علي تضمين ذلك في المناهج التعليمية والإعلامية بالتعاون مع الجهات المختصة واشراك الإعلام الرسمي والشعبي .

(ي) إجازة الهيكل التنظيمي للأمانة العامة .

(ك) وضع لائحة داخلية لتنظيم إجراءات اجتماعاته .

التنظيم الإداري للمجلس

٨. (١) يجتمع المجلس مرتين في العام علي الأقل ويجوز لرئيسه دعوته للانعقاد متي ما رأي ذلك ضرورياً ، وتحدد اللائحة الداخلية كيفية إدارة الاجتماعات والنصاب القانوني ونظام التصويت فيها .

(٢) تكون للمجلس أمانة عامة برئاسة أمين عام يعينه مجلس الوزراء بتوصية من رئيس المجلس ، وعضوية رؤساء أية مجالس فنية أو متخصصة يعينها المجلس .

(٣) تكون للأمانة العامة الاختصاصات الآتية :-

(أ) الإشراف علي جميع أعمال المجلس الإدارية والكتابية والمالية وشئون العاملين به ؛

(ب) إعداد جدول أعمال اجتماعات المجلس ولجانه الفنية بالتشاور مع رئيس المجلس .

(ج) تجميع الدراسات المتكاملة لتنمية البيئة والموارد الطبيعية وصيانتها واستخدامها وتنسيقها .

(د) إعداد البيانات والخرط اللازمة لرسم السياسات وتنفيذها بالتعاون مع الجهات المختصة حسبما يقرره المجلس .

(هـ) حفظ السجلات والمستندات وكل ما يتعلق بالنواحي الفنية والإدارية والمالية بمقر المجلس .

(و) أي اختصاصات أخرى يكلفه بها المجلس .

المجالس المتخصصة

٩ - (١) يجوز للمجلس أن ينشئ مجالس متخصصة ، على ان يراعي الاستفادة من المجالس المتخصصة القائمة .

(٢) تكون المجالس المتخصصة تحت إشراف الجهة المختصة التي يحددها المجلس .

(٣) تمارس المجالس المتخصصة الاختصاصات والسلطات الآتية وهي :-

(أ) تقديم المشورة الفنية إلى المجلس متى ما طلب منها ذلك ،

(ب) المساعدة في وضع السياسات العامة للمجلس .

(ج) تقويم البرامج والمشاريع التي تتمخض عن السياسات العامة .

الموارد المالية للمجلس

١٠ - تتكون الموارد المالية للمجلس من الآتي :-

(أ) ما تخصصه له الدولة من اعتمادات .

(ب) التبرعات والهبات والإعانات .

(ج) أي موارد أخرى يوافق عليها الوزير .

ميزانية المجلس

١١ - (١) تكون للمجلس ميزانية مستقلة تعد وفقاً للأسس المحاسبية السليمة .

(٢) يعد المجلس خلال ثلاثة اشهر قبل نهاية السنة المالية مقترحات الميزانية ويرفعها عن طريق رئيسه للجهات المختصة لإجازتها .

إيداع أمـوال المجلس

١٢ - (١) يودع المجلس أمواله في حسابات جارية أو حسابات إيداع لدى بنك السودان أو أي مصرف آخر يوافق عليه بنك السودان .

(٢) يتم التصرف في تلك الحسابات وفقاً للكيفية التي تحددها اللوائح .

الحسابات والمراجعة

١٣ (١) يحفظ المجلس حسابات منتظمة ودقيقة عن إيراداتـه ومصروفاته ، وفقـاً للأسس المحاسبية السليمة .

(٢) تراجع حسابات المجلس بوساطة ديوان المراجعة العامة وذلك بعد نهاية كل سـنة مالية .

المجالس الولائية

١٤ . ينشأ بكل ولاية ، بموجب قانون ولائي مجلس ولائي للبيئة والموارد الطبيعية ، ويشكل بقرار من الوالي ، برئاسة الوزير الولائـي المختص وعضـوية الوزراء ذوي الصلة بالبيئة والأجهزة والهيئات ذات الصلة ، وعدد من الأعضاء على أن تتوفر فيهم الدراية والخبرة في شئون البيئة والموارد الطبيعية .

اختصاصات المجلس الولائي

١٥ يمارس المجلس الولائي الاختصاصات الواردة في القانون الولائي ، على أن يراعي في ذلك الاختصاصات الممنوحة للمجلس وفقاً لأحكام هذا القانون ، والسياسات التي يضعها المجلس المذكور .

السـلطة المختصـة

١٦ - يعتبر كل من الأجهزة المذكـورة فيما يلي هو سـلطة مختصة بحمايـة البيئة والسعي لتحقيق الأهداف المنصوص عليها في المادة ٤ ، والأجهزة هي :-

(أ) المجلس وذلك وفقـاً للاختصاصات والسلطات المخـولة له بموجـب أحكـام هذا القانون .

(ب) الوزارات والأجهزة والمؤسسات الاتحادية المعنية بصحة وحماية البيئة في كافـة المجـالات الصحية والزراعية والصناعية والإسكانيـة والاقتصاديـة والثقافيـة والاجتماعية وغيرها وفقاً للسلطات الممنوحة لها بموجب القوانين سارية المفعول .

(ج) المجالس والوزارات الولائية والأجهزة والهيئات الولائية المختصة بحماية وترقية البيئة .

(د) الجمعيات والمؤسسات الوطنية والأجنبية المهتمة بترقية وحماية البيئة المصرح لها بالعمل في الدولة باعتبار أن حماية البيئة عمل شعبي يقتضي تمكين المجتمع من لعب دوره في تنظيم الجهد الشعبي علي المستويين الاتحادي والولائي .

(هـ) الإدارة الأهلية .

الفصل الثالث

السياسات والموجهات العامة لحماية البيئة

التقويم والمتابعة البيئية

١٧ (١) علي الرغم من أحكام أي قانون آخر بشأن تصديق السلطة المختصة علي المشاريع أو البرامج ، يجب علي كل شخص يرغب في الدخول في أي مشروع من المرجح أن يؤثر سلباً علي البيئة والموارد الطبيعية أن يتقدم بدراسة جدوى بيئية موقعاً عليها من قبل لجنة التقويم والمتابعة التي يشكلها المجلس .

(٢) يجب أن توضح دراسة الجدوى البيئية المشروع ما يأتي :-

(أ) الأثر المتوقع للمشروع المقترح علي البيئة .

(ب) الآثار السالبة للمشروع التي يمكن تفاديها عند تنفيذ المشروع .

(ج) البدائل المتاحة للمشروع المقترح .

(د) إيضاح كاف بأن استغلال الموارد الطبيعية والبيئية علي المدى القصير لا يؤثر علي عطاء تلك الموارد علي المدى البعيد .

(هـ) إذا ارتبط المشروع باستغلال الموارد الطبيعية غير المتجددة فيجب أن تضمن الدراسة المذكورة استمرار استغلال تلك الموارد .

(و) التحوطات المتخذة لاحتواء الآثار السالبة للمشروع والحد منها .

واجبات السلطة المختصة في مراعاة السياسات البيئية

١٨ نقوم السلطة المختصة بمراعاة واتباع السياسات والموجهات الآتية لحماية وترقية البيئة في الدولة :-

(أ) وضع واعتماد مستويات الجودة التي تؤدي إلي حماية البيئة ومنع تدهورها ، ومتابعة الإلتزام بها .

(ب) المحافظة علي مصادر المياه المختلفة وحمايتها من التلوث وترشيد استخدام المياه .

(ج) المحافظة علي الهواء والغذاء والتربة والغطاء النباتي وحمايتها من التلوث والتدهور .

(د) المحافظة علي الحيوانات والكائنات الحية الأخرى وحمايتها من مخاطر الانقراض بالصيد الجائر أو الاعتداء عليها .

(هـ) تطوير برامج التعدين والتنقيب وفقاً للمعايير والمواصفات البيئية السليمة .

(و) المحافظة علي المواقع الأثرية والسياحية وحمايتها من التدهور والاعتداءات عليها .

(ز) نشر الوعي والثقافة البيئية بين المواطنين وتنشيط دور الإعلام في مجال حماية البيئة .

(ح) تضمين مناهج العلوم والثقافة البيئية ضمن البرامج التعليمية بالمدارس والجامعات والمعاهد والمؤسسات التعليمية الأخرى بالدولة .

(ط) التنسيق والتعاون مع الجمعيات والمؤسسات والمجالس والشخصيات الاعتبارية الوطنية والأجنبية المختلفة المهتمة بالبيئة وحمايتها .

(ي) متابعة التنفيذ الصارم لأحكام القوانين البيئية دون المساس بالقوانين المنظمة للأجهزة العدلية .

واجب الكافة في الإبلاغ عن المخاطر

١٩ (١) يجب علي كل شخص سواء كان شخصاً طبيعياً أو اعتبارياً الإبلاغ عن المخاطر التي تهدد البيئة والمخالفات لأحكام هذا القانون وغيره من القوانين الأخرى المتعلقة بصحة وحماية البيئة وتقديم المساعدات والإمكانات المطلوبة لحماية البيئة ويكون له الحق في استرداد أي نفقات يتكبدها في سبيل أداء هذا الواجب من أي من

السلطات المختصة المعنية التي تقوم بأداء هذا الواجب نحوه .

(٢) مع مراعاة أحكام القوانين المنظمة للحقوق والإجراءات المدنية يكون لكل شخص الحق حسبة في رفع دعوى مدنية إذا حدث أي ضرر للبيئة دون الحاجة لإثبات علاقته بذلك الضرر .

الفصل الرابع

المخالفات والجزاءات والعقوبات

المخالفات

٢٠ على الرغم من أحكام أي قانون آخر يعتبر مخالفة لأحكام هذا القانون أي فعل من الأفعال الآتية :-

(أ) تلويث الهواء بإحداث أي تغيير في مكوناته كماً أو كيفاً بما من شأنه الإضرار بالإنسان والكائنات الحية الأخرى أو أي من عناصر البيئة .

(ب) تلويث مصادر المياه كالأنهار والبحار والبحيرات والبرك والجداول والترع والمجاري والمستودعات والخزانات المائية الطبيعية والصناعية وغيرها والتي تحفظ فيها المياه لاستخدام الإنسان أو الحيوان .

(ج) تلويث الغذاء بالكائنات الحية كالبكتريا الضارة والديدان والحشرات المسببة للأمراض أو بالمدخلات الطبيعية أو الصناعية أو بالكيماويات أو المعادن الثقيلة أو بالغبار بأنواعه أو الأتربة بأنواعها .

(د) تلويث التربة بإضافة مواد أو تركيبات ضارة بمكوناتها أو بزيادة نسبة الأملاح فيها عن الحد المعتاد أو بإلقاء القاذورات والمواد الطبيعية والصناعية الضارة بالصحة في التربة .

(هـ) التلويث الوبائي الذي يتسبب في الإصابة بالكائنات الدقيقة المعدية سريعة الانتشار كالكوليرا والطاعون والجذام وغيرها من الأمراض .

(و) التلويث الإشعاعي الناتج عن القيام بالتفجيرات النووية أو الانشطار الذري وخلافه .

(ز) التلويث الصوتي الناتج عن الأصوات العالية أو الضجيج أو الضوضاء .

(ح) التلويث الضوئي بتعريض أي شخص للإضاءة الصناعية الزائدة أو غير المناسبة .

المجلس الوطني

(ط) تلويث الفضاء الناتج عن العمليات الفيزيائية أو الكيميائية أو خلافها والذي يؤثر علي طبقات الغلاف الجوي للأرض أو الفضاء الخارجي .

(ي) تهديد الحيوانات والكائنات الحية الأخرى بالصيد الجائر أو الاعتداء علي بيئاتها ومحمياتها الطبيعية .

(ك) الإزالة والقطع الجائر للأشجار والتعدي علي الغطاء النباتي .

(ل) تغيير مسار المجاري الطبيعية للمياه والأنهار والأودية والسيول والتعدي عليها .

(م) نشر الكائنات المعدلة وراثياً دون الالتزام بالضوابط المنظمة لذلك .

العقوبات

٢١ (١) كل من يخالف أحكام المادة ٢٠ يعاقب بالسجن لمدة لا تجاوز ثلاث سنوات أو بالغرامة التي لا تجاوز مليون دينار سوداني أو بالعقوبتين معاً كما يجوز مصادرة المواد موضوع المخالفة لصالح السلطة المعنية بالمخالفة .

(٢) يجوز للمحكمة في حالة الإدانة إيقاف المشروع أو المنشأة أو المكان مصدر المخالفة كلياً أو جزئياً أو إلغاء الترخيص كلياً أو جزئياً ؛

(٣) تجوز مضاعفة العقوبة المنصوص عليها في البند (١) في حالة تكرار المخالفة .

(٤) يجوز الحكم بالتعويض لجبر الأضرار المادية الناجمة عن المخالفة لأحكام هذا القانون .

المحكمة المختصة

٢٢ ينعقد اختصاص محاكمة المخالفات لأحكام هذا القانون لمحاكم خاصة بالبيئة ينشؤها رئيس القضاء وتكون المحاكم الجنائية العادية مختصة في المناطق التي لا توجد فيها محاكم للبيئة .

توقيع العقوبة الأشد

٢٣ - إذا تعارضت العقوبة المنصوص عليها في المادة ٢١ مع أي عقوبة منصوص عليها في أي قانون آخر يعاقب عن نفس المخالفة يجب علي المحكمة توقيع العقوبة الأشد .

الفصل الخامس

أحكام عامة

معايير مكافحة التلوث ووسائله

٢٤ - تقوم الوزارة بالتنسيق مع المجلس والسلطة المختصة المعنية بتحديد معايير ووسائل مكافحة التلوث والحد منه في المجالات المختلفة وذلك بغرض الإعلان عنها ونشرها بكافة طرق الإعلام .

إجراءات دخول المنشآت وتفتيشها

٢٥ - يجوز للسلطة المختصة بعد الحصول على إذن النيابة المختصة دخول وتفتيش أي منشأة أو مشروع أو مكان أو خلافه وذلك لضبط أو وقف أو منع المخالفات لأحكام هذا القانون

تطبيق أحكام الاتفاقيات الدولية

٢٦ - دون الإخلال بأي أحكام أخرى في هذا القانون تلتزم السلطة المختصة بتطبيق أحكام الاتفاقيات والبروتوكولات الثنائية والدولية التي وافقت عليها الدولة أو التي توافق عليها أو تنضم إليها مستقبلاً .

سلطة إصدار اللوائح

٢٧ - يجوز للمجلس بموافقة الوزير إصدار اللوائح اللازمة لتنفيذ أحكام هذا القانون .

شـــــــهادة

بهذا أشهد بأن المجلس الوطني أجاز قانون حماية البيئة لسنة ٢٠٠١م في جلسته رقم (٣٥) من دورة الانعقاد الأول بتاريخ ١٤ ربيع أول ١٤٢٢هـ الموافق ٥ يونيو ٢٠٠١م .

أحمد ابراهيم الطاهر

رئيس المجلس الوطني

Annex IV

Industrial Waste Local Order 1971 of Khartoum North Municipal Council

- Part I General
- Part II Definitions
- Part III General Provisions Minimum Standards

III Industrial Waste Pre-treatment or Disposal

Industrial waste treatment facilities shall be installed – when ever the council shall find that such facilities are required to safe guard the public health ; and water, prevent pollution of streems, bodies of surface or underground reservoirs either natural or artificial, prevent damage or increased maintenance costs in the sewerage system, prevent damage to the public or private property, prevent a public nuisance, or prevent over – loading on the treatment plant.

III . II - Industrial Waste Pre-treatment facilities

- Part IV Special Conditions Discharge of Industrial Liquid Waste To the Public Sewer

--- 23 Temperature Conditions

No Person shall discharge into the public sewer any industrial wastewater or liquids having a temperature exceeding (60) degrees centigrade except upon advance permission of the council.

--- 24 pH

No waste shall be allowed in any public sewer below pH (5.5) or above pH 10.0, provided, however, that where large flows are involved the contributing waste must not place the total combined waste at a public treatment plant in pH range below 6.5 or above 9.0.

---25 <u>Grease and Oil</u>

No waste shall be allowed in any public sewer with grease or oil content above 150 mg/L provided however, that following installation of an approved grease trap, the effluent from the trap will be allowed as long as the trap is operated in an approved manner.

---26 <u>Suspended Solids and BOD</u>

No waste shall be allowed in any public sewer with suspended solids or a BOD content greater than 800 mg/L ; provided, however, that following installation of approved pre-treatment facilities are operated in approved manner.

---27 Petroleum Products

No petroleum products, calcium carbide, cleaning solvents, fuel oil, benzol or other inflammable or explosive substance shall be allowed in any public sewer with a flash point than eighty five (85) degrees centigrade.

---28 Malodorous Gases

Malodorous gases and acetylene generation sludges shall not be allowed in any public sewer. Hydrogen sulphide, sulphur dioxide, nitrous oxide or any of the halogens shall not exceed a concentration of 10 mg/L in the contribution waste.

---29 Sulphur

Inorganic sulphites, sulphides, and sulphurous materials shall not be allowed in any public sewer with a concentration greater than 10 mg/L in the contribution waste.

---30 Yeast

Living organisms present in industrial wastes, such as yeast, shall not be allowed in any public sewer unless they are treated to prevent further growth.

---31 Minerals

No cyanide, chromium, or other dangerous metals of any higher concentration than in the table shown below shall not be allowed in any public sewer.

Metal	Concentration in mg $^{-l}$
Fe and Mn	5.0
Cr	1.0
Cu	0.2
Co	0.1
Zn	0.3
Ni	2.0

Appendix V

University of Khartoum

Institute of Environmental Studies

Study on Industrial Wastes in Omdurman Industrial Area

Questionnaire (1)

Date :...............

Section (A) General:

a) **Identification:**

1. Serial No:____________________
2. Name of interviewer:_________________________
3. Name of Factory or Industry:___________________________________
4. Location:________________ Block No:_______________________
5. Type of Industry:____
6. Date of establishment:_______________________________________
7. Ownership:____

   i) Private Individual ( )

   ii) Company ( )

   iii) Public/Private Sector ( )

   iv) Co-operative ( )

b) **Employment conditions:**

   i) No. of employees

   a) No. of males.............. b) No. of females...............

   ii) No. of employees involved in waste disposal ?...........

   ....

   a) Temporary................... b) Permanent.....................

   c) No. of males................. Females..................

   d) Proportion of waste labour to the total No. of employees.....

   ....

iii) Types of labour used in waste disposal?

a) high skilled ( )

b) skilled ( )

c) unskilled ( )

c) Services provided to waste disposal employees?

1. Medical ( )

2. Free transportation ( )

3. Meals ( )

4. Clothes : a) Normal ( )

b) Special protective ( )

5. Recreation facilities ( )

6. Financial help in case of sad or happy events........................

...........................( )

7. Any other extra incentives...

d) Does the factory provide insurance facilities for waste handling employees?

Yes ( ) No ( )

If yes specify...

i) Against diseases ( )

ii) Against disablements ( )

iii) Death ( )

iv) Others ( )

Annual Estimated Cost of :

1. Insurance ? .... 2. Services ....

If No from where do waste employees obtain services ?

....

Section (B) Technical

1) Working conditions :

i) working days/year ....

ii) Working hours/day........................

iii) No. of shifts/day.........................

2) Type of raw material used (chemical and biological)...........

.................................volume..............................

3) Volume of final product..

4) Capacity of the factory...

5) Source of water used...

....

6) Factory water requirements ? (volume).........................

1. a) potable water...............gal or m^3/day

b) for product use.............gal or m^3/day

2. Softening water...............degree of softening..........

....

3. Cooling water....................temp................

4. Wash down water.................. gal, m^3/day

5. Clarified water..................... gal or m^3/day

6. Demineralized water............. gal or m^3/day

7. Power source and type.......................................

....

Consumption..

8. Type of waste produced.......................................

....

9. Volume of waste per year...................................

Max. per day...........................

Minimum per day......................

10. Type of waste treatment ?

i) Pretreatment ( )

ii) complete treatment ( )

11. What disposal systems used at present......................

....

12. Is there sufficient area for a treatment plant in or close to

The property ?..

....

13. Is the factory people interested in recovery of any

waste component ?..

If yes determine the feasibility, and give information about

The component recovered at the current market value ?...

....

....

14.Effluent waste characteristics....................................

a) Liquid waste : Rate ....

pH......................	Turbidity.........................
Temp....................	S.S..................
Odour....................	T.S...........................
Colour..................	BOD.........................
	COD........................
	Oil content ....

b) Solid Waste

1. Sources................................

2. Composition..................(see raw materials for heavy metals and other toxic materials)...........

....

3. Methods of collection..............................

4. Methods of treatment and disposal.............

....

5. Volume per year..

15.Do you think that the industrial area, activities

adversely affects the environment of the town ?

Yes (   )   No (   )

16. Can you help in improving the environmental conditions of the industrial area?

Yes (   )   No (   )

If Yes in what way ?..

....

17. Are there difficulties in disposing the wastes ?

Yes (   )   No (   )

If yes what are the difficulties ....

With solid waste

With liquid.

18. Do you give training to waste employees ?

Yes (   )   specify ....

No (   )

19. Do you hold periodic meetings to discuss waste problems:

Yes (   )   No (   )

20. What are the effects of wastes on the factory environment :

i) On the employees ....

ii) On the buildings..................................

iii) On the machines and equipments................

....

Section (C) Economic

1. Capital ....

   i) Capital involved ? ....

   ii) Running cost ? ....

2. Annual capacity of the factory.............................

3. Present annual costs of waste disposal ?

   i) Wages ? ....

ii) Material ? ....

iii) Equipments? ....

iv) Services ? ....

v) Others ? ....specify.................

4) Effects of seasons on production, and wastes disposal ?

a) Maximum ?..............................

b) Minimum ?................................

c) Cost ? ....

5) What are the total wages of employees involved in waste disposal? Per month................................

per year,...

6) Is there any emendable suggestions to change in productive processes to reduce the volume and composition of wastes to reduce treatment cost ?............................

....

7) Does locality benefit from the services of any treatment plant?

....

If Yes on what bases do you treat in the plant?

a) Payment i)Liquid.................

ii)Solid.................

b) Volume or concentration of certain ingredient ?

....

....

University of Khartoum
Institute of Environmental Studies
Omdurman Industrial Waste

Questionnaire (2)

Date :......................

1) Serial No............................
2) Name of Interviewer.................................
3) Job of Interviewee..................................
4) Age of Interviewee...................................
5) Marital status..................................
   i) Single.........
   ii) Married...............
   iii) If married, No. of children ?...............
   iv) Do you send your children to school ?
   Yes ( ) No ( )
6) Home province ? ....
7) Have you had any education ?
   Yes ( ) No ( )
   If Yes No. of years
8) Employment state ?.................
   i) temporary ( ) ii) Permanent ( )
9) Are you satisfied with this job at present?
   Yes ( ) .... why ?
   No ( )..................why ?
10) Have you got any other Job ?
   Yes ( ) No ( )
   If yes what is it ? ....
   How much you earn from that job ?
11) For how long have you been working in waste disposal ?
   ....
12) Would you like to change your job?
   Yes ( ) No ( )
   Why ....
   ....

13) Do you work overtime hours ?

Yes ( ) No ( )

If yes how many hours/day?............................

Money earned ?....................................

14) Do you live near the industrial area ?

Yes ( ) No ( )

If yes is there any inconvenience caused to your family by :

Odours ( ) Noise ( )

Street congestion ( ) Others ( )

Specify..

If no how far do you live..

15) Do you make use of industrial wastes ?

Yes ( ) No ( )

If yes specify (how much).........in Dinnar..........

16) Do you wash yourself after work ends ?

Yes ( ) No ( )

If yes is it : with soap ?............................

Only water ?.....................

Others ? .... Specify.................

17) Is there any services provided to you by the factory ?

Yes ( ) No ( )

If yes is it : Medical ? ....

Clothes ?.......................................

Free transportation ? ....

Meals ?..

Others ? ....

Specify.......................................

18) How many hours do you work/day..............................

i) During night?.....................................

ii) Partly daily, and partly nightly ?........................

19) Does your job cause you any diseases ?

Yes ( ) No ( )

If yes (specify)..

a) Allergy ....( )

b) Chest disease...........( )

c) Eye disease.............( )

d) Skin diseases...........( )

e) Accidents.............( )

g) Others................( ) specify..............

20) Have you been admitted to hospital last year?

Yes ( ) No ( )

If yes diseases ? ....

Duration?............................

21) Do you have any extended family?

Yes ( ) No ( )

If yes do you send them money ?

Yes ( ) How much ? ....

No ( ).........Why ? ....

22) How frequent do you visit your home province ?

a) Weakly ( )

b) Monthly ( )

c) Six monthly ( )

d) Annually ( )

e) Others ( )

23) Is the condition inside the factory healthy ?

Yes ( )

No ( )

If No specify why?...............................

24) Do you have problems with public ?

Yes ( )..................

No ( )..................

If yes explain ....

Appendix VI: Studied Industries Effluent characteristics

Elmadeh Oil Mills waterwaste analysis

BOD mg/l	COD Mg/l	O&G mg/l	T.S mg/l	D.S mg/l	S.S mg/l	pH	Temp °C	Conductivity mScm-1
996	1636	6847	180300	94200	86100	12.8	42	187.8
990	1615	13189	176000	92800	83200	12.4	40	181.6
896	1472	10018	167100	88500	78600	11.7	51	169.2

Babiker Oil Mills Effluent wastewater analysis

BOD mg/l	COD Mg/l	O&G mg/l	T.S mg/l	D.S Mg/l	S.S mg/l	PH	Temp °C	Conductivity mScm-1
978	1494	7947	144100	80700	63400	10.1	40	162.7
953	1563	7932	140300	78600	61700	9.9	42	158
958	1569	7939	142000	79700	92300	9.4	45	163

Suliman Tannery Effluent Wastewater Analysis

BOD mg/l	COD mg/l	Cr mg/l	T.S mg/l	D.S Mg/l	S.S mg/l	pH	Temp °C	Conductivity MScm-1
974	1814	5.8	37400	10100	27300	12.1	22	20.2
962	1791	5.4	31400	7800	23600	11.8	25	15.9
984	1821	6.5	42500	11700	30800	11.8	25	24.8

Nile Soft Drinks Bottling Factory Effluent Wastewater Analysis

BOD mg/l	COD mg/l	T.S mg/l	D.S mg/l	S.S mg/l	pH	Temp °C	Conductivity mScm-1
89.1	109.6	270	200	70	8.4	33	0.383
165	203	500	380	120	8.8	35	0.71
186	214	590	410	180	8.6	22	0.812

Tagoug Soap Factory Effluent Wastewater Analysis

BOD mg/l	COD mg/l	O&G mg/l	T.S mg/l	D.S mg/l	S.S mg/l	PH	Temp °C	Conductivity mScm-1
661	918	17930	71400	39800	31600	10.7	62	80.9
668	941	3780	81500	43400	38100	12.8	76	86.8
665	928	10855	79500	42800	36700	12.4	73	84.6

Tawfig Soap Factory Effluent Wastewater Analysis

BOD mg/l	COD Mg/l	O&G mg/l	T.S mg/l	D.S mg/l	S.S mg/l	PH	Temp °C	Conductivity mScm-1
675	968	907	85100	45200	39900	10.4	47	98.1
681	972	860	92400	49600	42800	10.8	55	97.4
684	985	883	97500	48300	39200	12.6	47	88.2

National Industries Sweetes and Biscuits Effluent Wastewater Analysis

BOD mg/l	COD mg/l	T.S Mg/l	D.S mg/l	S.S mg/l	PH	Temp °C	Conductivity mScm-1
978	1591	145700	82300	63400	9.6	22	165.3
972	1588	144500	79700	64800	9.8	20	160.3
986	1605	150800	82500	68300	9.6	24	166.2

Yareem Tahnia Factory Effluent Wastewater Analysis

BOD mg/l	COD mg/l	T.S Mg/l	D.S mg/l	S.S mg/l	PH	Temp °C	Conductivity mScm-1
982	1580	141500	80800	60700	10.3	25	161.9
885	1428	148400	82600	65800	9.6	23	166.7
878	1412	157200	87900	69300	9.8	25	175.9

2540 C. Total Dissolved Solids Dried at 180°C

1. General Discussion

a. Principle: A well-mixed sample is filtered through a standard glass fiber filter, and the filtrate is evaporated to dryness in a weighed dish and dried to constant weight at 180°C. The increase in dish weight represents the total dissolved solids.

The results may not agree with the theoretical value for solids calculated from chemical analysis of sample (see above). Approximate methods for correlating chemical analysis with dissolved solids are available.[1] The filtrate from the total suspended solids determination (Section 2540D) may be used for determination of total dissolved solids.

b. Interferences: Highly mineralized waters with a considerable calcium, magnesium, chloride, and/or sulfate content may be hygroscopic and require prolonged drying, proper desiccation, and rapid weighing. Samples high in bicarbonate require careful and possibly prolonged drying at 180°C to insure complete conversion of bicarbonate to carbonate. Because excessive residue in the dish may form a water-trapping crust, limit sample to no more than 200 mg residue.

2. Apparatus

Apparatus listed in 2540B.2*a-d* is required, and in addition:

*a. Glass-fiber filter disks** without organic binder.

b. Filtration apparatus: One of the following, suitable for filter disk selected:

1) *Membrane filter funnel.*

2) *Gooch crucible,* 25-mL to 40-mL capacity, with Gooch crucible adapter.

3) *Filtration apparatus* with reservoir and coarse (40- to 60-μm) fritted disk as filter support.

c. Suction flask, of sufficient capacity for sample size selected.

d. Drying oven, for operation at 180 ± 2°C.

3. Procedure

a. Preparation of glass-fiber filter disk: Insert disk with wrinkled side up into filtration apparatus. Apply vacuum and wash disk with three successive 20-mL volumes of distilled water. Continue suction to remove all traces of water. Discard washings.

b. Preparation of evaporating dish: If volatile solids are to be measured, ignite cleaned evaporating dish at 550 ± 50°C for 1 h in a muffle furnace. If only total dissolved solids are to be measured, heat clean dish to 180 ± 2°C for 1 h in an oven. Store in desiccator until needed. Weigh immediately before use.

c. Selection of filter and sample sizes: Choose sample volume to yield between 2.5 and 200 mg dried residue. If more than 10 min are required to complete filtration, increase filter size or decrease sample volume but do not produce less than 2.5 mg residue.

d. Sample analysis: Filter measured volume of well-mixed sample through glass-fiber filter, wash with three successive 10-mL volumes of distilled water, allowing complete drainage between washings, and continue suction for about 3 min after filtration is complete. Transfer filtrate to a weighed evaporating dish and evaporate to dryness on a steam bath. If filtrate volume exceeds dish capacity add successive por-

*Whatman grade 934AH; Gelman type A/E; Millipore type AP40; E-D Scientific Specialties grade 161; or equivalent. Available in diameters of 2.2 cm to 4.7 cm.

tions to the same dish after evaporation. Dry for at least 1 h in an oven at 180 ± 2°C, cool in a desiccator to balance temperature, and weigh. Repeat drying cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until weight loss is less than 4% of previous weight or 0.5 mg, whichever is less.

4. Calculation

$$\text{mg total dissolved solids/L} = \frac{(A - B) \times 1000}{\text{sample volume, mL}}$$

where:

A = weight of dried residue + dish, mg, and
B = weight of dish, mg.

5. Precision

Single-laboratory analyses of 77 samples of a known of 293 mg/L were made with a standard deviation of differences of 21.20 mg/L.

6. Reference

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2540 D. Total Suspended Solids Dried at 103–105°C

1. General Discussion

a. Principle: A well-mixed sample is filtered through a weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight at 103 to 105°C. The increase in weight of the filter represents the total suspended solids. If the suspended material clogs the filter and prolongs filtration, the difference between the total solids and the total dissolved solids may provide an estimate of the total suspended solids.

b. Interferences: Exclude large floating particles or submerged agglomerates of nonhomogeneous materials from the sample if it is determined that their inclusion is not desired in the final result. Because excessive residue on the filter may form a water-entrapping crust, limit the sample size to that yielding no more than 200 mg residue. For samples high in dissolved solids thoroughly wash the filter to ensure removal of the dissolved material. Prolonged filtration times resulting from filter clogging may produce high results owing to excessive solids capture on the clogged filter.

2. Apparatus

Apparatus listed in Sections 2540B.2 and 2540C.2 is required, except for evaporating dishes, steam bath, and 180°C drying oven. In addition:

*Planchet,** aluminum or stainless steel, 65-mm diam.

3. Procedure

a. Preparation of glass-fiber filter disk: Insert disk with wrinkled side up in filtra-

*Available from New England Nuclear, Boston, Mass., or equivalent.

tion apparatus. Apply vacuum and wash disk with three successive 20-mL portions of distilled water. Continue suction to remove all traces of water, and discard washings. Remove filter from filtration apparatus and transfer to an aluminum or stainless steel planchet as a support. Alternatively remove crucible and filter combination if a Gooch crucible is used. Dry in an oven at 103 to 105°C for 1 h. If volatile solids are to be measured, ignite at 550 ± 50°C for 15 min in a muffle furnace. Cool in desiccator to balance temperature and weigh. Repeat cycle of drying or igniting, cooling, desiccating, and weighing until a constant weight is obtained or until weight loss is less than 0.5 mg between successive weighings. Store in desiccator until needed. Weigh immediately before use.

b. Selection of filter and sample sizes: See Section 2540C.3c. For nonhomogeneous samples such as raw wastewater, use a large filter to permit filtering a representative sample.

c. Sample analysis: Assemble filtering apparatus and filter and begin suction. Wet filter with a small volume of distilled water to seat it. Filter a measured volume of well-mixed sample through the glass fiber filter. Wash with three successive 10-mL volumes of distilled water, allowing complete drainage between washings and continue suction for about 3 min after filtration is complete. Carefully remove filter from filtration apparatus and transfer to an aluminum or stainless steel planchet as a support. Alternatively, remove the crucible and filter combination from the crucible adapter if a Gooch crucible is used. Dry for at least 1 h at 103 to 105°C in an oven, cool in a desiccator to balance temperature, and weigh. Repeat the cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until the weight loss is less than 4% of the previous weight or 0.5 mg, whichever is less.

4. Calculation

$$\text{mg total suspended solids/L} = \frac{(A - B) \times 1000}{\text{sample volume, mL}}$$

where:

A = weight of filter + dried residue, mg, and

B = weight of filter, mg.

5. Precision

The standard deviation was 5.2 mg/L (coefficient of variation 33%) at 15 mg/L, 24 mg/L (10%) at 242 mg/L, and 13 mg/L (0.76%) at 1707 mg/L in studies by two analysts of four sets of 10 determinations each.

Single-laboratory duplicate analyses of 50 samples of water and wastewater were made with a standard deviation of differences of 2.8 mg/L.

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3500-Cr B. Atomic Absorption Method for Total Chromium

See flame atomic absorption spectrometric method, Sections 3111B and C, and electrothermal atomic absorption spectrometric method, Section 3113.

3500-Cr C. Inductively Coupled Plasma Method

See Section 3120.

3500-Cr D. Colorimetric Method

1. General Discussion

a. Principle: This procedure measures only hexavalent chromium (Cr^{6+}). Therefore, to determine total chromium convert all the chromium to the hexavalent state by oxidation with potassium permanganate. The hexavalent chromium is determined colorimetrically by reaction with diphenylcarbazide in acid solution. A red-violet color of unknown composition is produced. The reaction is very sensitive, the molar absorptivity based on chromium being about 40 000 L g^{-1} cm^{-1} at 540 nm. To determine total chromium, digest the sample with a sulfuric-nitric acid mixture and then oxidize with potassium permanganate before reacting with the diphenylcarbazide.

b. Interferences: The reaction with diphenylcarbazide is nearly specific for chromium. Hexavalent molybdenum and mercury salts will react to form color with the reagent but the intensities are much lower than that for chromium at the specified pH. Concentrations as high as 200 mg Mo or Hg/L can be tolerated. Vanadium interferes strongly but concentrations up to 10 times that of chromium will not cause trouble. Potential interference from permanganate is eliminated by prior reduction with azide. Iron in concentrations greater than 1 mg/L may produce a yellow color but the ferric ion (Fe^{3+}) color is not strong and no difficulty is encountered normally if the absorbance is measured photometrically at the appropriate wavelength. Interfering amounts of molybdenum, vanadium, iron, and copper can be removed by extraction of the cupferrates of these metals into chloroform ($CHCl_3$). A procedure for this extraction is provided, but do not use it unless necessary, because residual cupferron and $CHCl_3$ in the aqueous solution complicate the later oxidation. Therefore, follow the extraction by additional treatment with acid fuming to decompose these compounds.

2. Apparatus

a. Colorimetric equipment: One of the following is required:

1) *Spectrophotometer,* for use at 540 nm, with a light path of 1 cm or longer.

2) *Filter photometer,* providing a light path of 1 cm or longer and equipped with a greenish yellow filter having maximum transmittance near 540 nm.

b. Separatory funnels, 125-mL, Squibb form, with glass or TFE stopcock and stopper.

3. Reagents

Use redistilled water to prepare reagents.

a. Stock chromium solution: Dissolve 141.4 mg $K_2Cr_2O_7$ in water and dilute to 1000 mL; 1.00 mL = 50.0 μg Cr.

b. Standard chromium solution: Dilute 10.0 mL stock chromium solution to 100 mL; 1.00 mL = 5.00 μg Cr.

c. Nitric acid, HNO_3, conc.

d. Sulfuric acid, H_2SO_4, 1 + 1.

e. Methyl orange indicator solution.

f. Hydrogen peroxide, H_2O_2, 30%.

g. Redistilled water: Distilled water redistilled in all-glass apparatus.

h. Ammonium hydroxide, NH_4OH, conc.

i. Potassium permanganate solution: Dissolve 4 g $KMnO_4$ in 100 mL water.

j. Sodium azide solution: Dissolve 0.5 g NaN_3 in 100 mL water.

k. Diphenylcarbazide solution: Dissolve 250 mg 1,5-diphenylcarbazide (1,5-diphenylcarbohydrazide) in 50 mL acetone. Store in a brown bottle. Discard when solution becomes discolored.

l. Chloroform, $CHCl_3$: Avoid or redistill material that comes in containers with metal or metal-lined caps.

m. Cupferron solution: Dissolve 5 g $C_6H_5N(NO)ONH_4$ in 95 mL water.

n. Phosphoric acid, H_3PO_4, conc.

o. Sulfuric acid, H_2SO_4, 0.2*N:* Dilute 17 mL 6*N* H_2SO_4 to 500 mL with water.

4. Procedure

a. Preparation of calibration curve: To compensate for possible slight losses of chromium during digestion or other analytical operations, treat chromium standards by the same procedure as the sample. Accordingly, pipet measured volumes of standard chromium solution (5 μg/mL) ranging from 2.00 to 20.0 mL, to give standards for 10 to 100 μg Cr, into 250-mL beakers or conical flasks. Depending on pretreatment used in ¶ *b* below, proceed with subsequent treatment of standards as if they were samples, also carrying out cupferron treatment of standards if this is required for samples.

Develop color as for samples, transfer a suitable portion of each colored solution to a 1-cm absorption cell, and measure absorbance at 540 nm. As reference, use distilled water. Correct absorbance readings of standards by subtracting absorbance of a reagent blank carried through the method.

Construct a calibration curve by plotting corrected absorbance values against micrograms chromium in 102 mL final volume.

b. Treatment of sample: If sample has been filtered and acidified and only hexavalent chromium is desired, proceed to ¶ 4*e*. If total dissolved chromium is desired and there are interfering amounts of molybdenum, vanadium, copper, or iron present, proceed to ¶ 4*c*. If interferences are not present, proceed to ¶ 4*d*. If sample is unfiltered and total chromium is desired, digest with HNO_3 and H_2SO_4 as in Section 3030G. If interferences are present, proceed to ¶s 4*c*, 4*d*, and 4*e*. If there are no interferences, proceed to ¶s 4*d* and 4*e*.

c. Removal of molybdenum, vanadium, iron, and copper with cupferron: Pipet a portion of digested sample containing 10 to 100 μg Cr into a 125-mL separatory funnel. Dilute to about 40 mL with distilled water and chill in an ice bath. Add 5 mL ice-cold cupferron solution, shake well, and let stand in ice bath for 1 min. Extract in separatory funnel with three successive 5-mL portions of $CHCl_3$; shake each portion thoroughly with aqueous solution, let layers separate, and withdraw and discard

$CHCl_3$ extract. Transfer extracted aqueous solution to a 125-mL conical flask. Wash separatory funnel with a small amount of distilled water and add wash water to flask. Boil for about 5 min to volatilize $CHCl_3$ and cool. Add 5 mL HNO_3 and sufficient H_2SO_4 to have about 3 mL present. Boil samples to the appearance of SO_3 fumes. Cool slightly, carefully add 5 mL HNO_3, and again boil to fumes to complete decomposition of organic matter. Cool, wash sides of flask, and boil once more to SO_3 fumes to eliminate all HNO_3. Cool and add 25 mL water.

d. Oxidation of trivalent chromium: Pipet a portion of digested sample with or without interferences removed, and containing 10 to 100 µg Cr, into a 125-mL conical flask. Using methyl orange as indicator, add conc NH_4OH until solution is just basic to methyl orange. Add 1 + 1 H_2SO_4 dropwise until it is acidic, plus 1 mL (20 drops) in excess. Adjust volume to about 40 mL, add a boiling chip, and heat to boiling. Add 2 drops $KMnO_4$ solution to give a dark red color. If fading occurs, add $KMnO_4$ dropwise to maintain an excess of about 2 drops. Boil for 2 min longer. Add 1 mL NaN_3 solution and continue boiling gently. If red color does not fade completely after boiling for approximately 30 s, add another 1 mL NaN_3 solution. Continue boiling for 1 min after color has faded completely, then cool. Add 0.25 mL (5 drops) H_3PO_4.

e. Color development and measurement: Use 0.2*N* H_2SO_4 and a pH meter to adjust solution to pH 1.0 ± 0.3. Transfer solution to a 100-mL volumetric flask, dilute to 100 mL, and mix. Add 2.0 mL diphenylcarbazide solution, mix, and let stand 5 to 10 min for full color development. Transfer an appropriate portion to a 1-cm absorption cell and measure its absorbance at 540 nm. Use distilled water as reference. Correct absorbance reading of sample by subtracting absorbance of a blank carried through the method (see also note below). From the corrected absorbance, determine micrograms chromium present by reference to the calibration curve.

NOTE: If the solution is turbid after dilution to 100 mL in ¶ *e* above, take an absorbance reading before adding carbazide reagent and correct absorbance reading of final colored solution by subtracting the absorbance measured previously.

5. Calculation

$$\text{mg Cr/L} = \frac{\mu\text{g Cr (in 102 mL final volume)}}{A \times B} \times 100$$

where:

A = mL original sample, and
B = mL portion from 100 mL digested sample.

6. Precision and Bias

The dissolved (trivalent plus hexavalent) chromium was determined in 31 laboratories in a synthetic sample containing 110 µg Cr/L, 500 µg Al/L, 50 µg Cd/L, 470 µg Ca/L, 300 µg Fe/L, 70 µg Pb/L, 120 µg Mn/L, 150 µg Ag/L, and 650 µg Zn/L in distilled water. The relative standard deviation was 47.8% and the relative error 16.3%.

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5210 B. 5-Day BOD Test

1. General Discussion

a. Principle: The method consists of filling with sample, to overflowing, an airtight bottle of the specified size and incubating it at the specified temperature for 5 d. Dissolved oxygen is measured initially and after incubation, and the BOD is computed from the difference between initial and final DO. Because the initial DO is determined immediately after the dilution is made, all oxygen uptake, including that occurring during the first 15 min, is included in the BOD measurement.

b. Sampling and storage: Samples for BOD analysis may degrade significantly during storage between collection and analysis, resulting in low BOD values. Minimize reduction of BOD by analyzing sample promptly or by cooling it to near-freezing temperature during storage. However, even at low temperature, keep holding time to a minimum. Warm chilled samples to 20°C before analysis.

1) Grab samples—If analysis is begun within 2 h of collection, cold storage is unnecessary. If analysis is not started within 2 h of sample collection, keep sample at or below 4°C from the time of collection. Begin analysis within 6 h of collection; when this is not possible because the sampling site is distant from the laboratory, store at or below 4°C and report length and temperature of storage with the results. In no case start analysis more than 24 h after grab sample collection. When samples are to be used for regulatory purposes make every effort to deliver samples for analysis within 6 h of collection.

2) Composite samples—Keep samples at or below 4°C during compositing. Limit compositing period to 24 h. Use the same criteria as for storage of grab samples, starting the measurement of holding time from end of compositing period. State storage time and conditions as part of the results.

2. Apparatus

a. Incubation bottles, 250- to 300-mL capacity. Clean bottles with a detergent, rinse thoroughly, and drain before use. As a precaution against drawing air into the dilution bottle during incubation, use a water-seal. Obtain satisfactory water seals by inverting bottles in a water bath or by adding water to the flared mouth of special BOD bottles. Place a paper or plastic cup or foil cap over flared mouth of bottle to reduce evaporation of the water seal during incubation.

b. Air incubator or water bath, thermostatically controlled at 20 ± 1°C. Exclude all light to prevent possibility of photosynthetic production of DO.

3. Reagents

a. Phosphate buffer solution: Dissolve 8.5 g KH_2PO_4, 21.75 g K_2HPO_4, 33.4 g $Na_2HPO_4\cdot 7H_2O$, and 1.7 g NH_4Cl in about

about 500 mL distilled water and dilute to 1 L. The pH should be 7.2 without further adjustment. Discard reagent (or any of the following reagents) if there is any sign of biological growth in the stock bottle.

b. Magnesium sulfate solution: Dissolve 22.5 g $MgSO_4 \cdot 7H_2O$ in distilled water and dilute to 1 L.

c. Calcium chloride solution: Dissolve 27.5 g $CaCl_2$ in distilled water and dilute to 1 L.

d. Ferric chloride solution: Dissolve 0.25 g $FeCl_3 \cdot 6H_2O$ in distilled water and dilute to 1 L.

e. Acid and alkali solutions, 1N, for neutralization of caustic or acidic waste samples.

1) Acid—Slowly and while stirring, add 28 mL conc sulfuric acid to distilled water. Dilute to 1 L.

2) Alkali—Dissolve 40 g sodium hydroxide in distilled water. Dilute to 1 L.

f. Sodium sulfite solution: Dissolve 1.575 g Na_2SO_3 in 1000 mL distilled water. This solution is not stable; prepare daily.

g. Nitrification inhibitor, 2-chloro-6-(trichloro methyl) pyridine.*

h. Glucose-glutamic acid solution: Dry reagent-grade glucose and reagent-grade glutamic acid at 103°C for 1 h. Add 150 mg glucose and 150 mg glutamic acid to distilled water and dilute to 1 L. Prepare fresh immediately before use.

i. Ammonium chloride solution: Dissolve 1.15 g NH_4Cl in about 500 mL distilled water, adjust pH to 7.2 with NaOH solution, and dilute to 1 L. Solution contains 0.3 mg N/mL.

4. Procedure

a. Preparation of dilution water: Place desired volume of water in a suitable bottle and add 1 mL each of phosphate buffer, $MgSO_4$, $CaCl_2$, and $FeCl_3$ solutions/L of water. Seed dilution water, if desired, as described in ¶ 4d. Test and store dilution water as described in ¶s 4b and c so that water of assured quality always is on hand.

Before use bring dilution water temperature to 20°C. Saturate with DO by shaking in a partially filled bottle or by aerating with organic-free filtered air. Alternatively, store in cotton-plugged bottles long enough for water to become saturated with DO. Protect water quality by using clean glassware, tubing, and bottles.

b. Dilution water check: Use this procedure as a rough check on quality of dilution water.

If the oxygen depletion of a candidate water exceeds 0.2 mg/L obtain a satisfactory water by improving purification or from another source. Alternatively, if nitrification inhibition is used, store the dilution water, seeded as prescribed below in a darkened room at room temperature until the oxygen uptake is sufficiently reduced to meet the dilution-water check criteria. Check quality of stored dilution water on use, but do not add seed to dilution water stored for quality improvement. Storage is not recommended when BODs are to be determined without nitrification inhibition because nitrifying organisms may develop during storage. Check stored dilution water to determine whether sufficient ammonia remains after storage. If not, add ammonium chloride solution to provide a total of 0.45 mg ammonia/L as nitrogen. If dilution water has not been stored for quality improvement add sufficient seeding material to produce a DO uptake of 0.05 to 0.1 mg/L in 5 d at 20°C. Incubate a BOD bottle full of dilution water for 5 d at 20°C. Determine initial and final DO as in ¶s 4g and j. The DO uptake in 5 d at 20°C should not be more than 0.2 mg/L and preferably not more than 0.1 mg/L.

c. Glucose-glutamic acid check: Because the BOD test is a bioassay its results can be influenced greatly by the presence of toxicants or by use of a poor seeding im-

*Nitrification Inhibitor 2579-24 (2.2% TCMP), Hach Co., or equivalent.

terial. Distilled waters frequently are contaminated with copper; some sewage seeds are relatively inactive. Low results always are obtained with such seeds and waters. Periodically check dilution water quality, seed effectiveness, and analytical technique by making BOD measurements on pure organic compounds and samples with known additions. In general, for BOD determinations not requiring an adapted seed, use a mixture of 150 mg glucose/L and 150 mg glutamic acid/L as a "standard" check solution. Glucose has an exceptionally high and variable oxidation rate but when it is used with glutamic acid, the oxidation rate is stabilized and is similar to that obtained with many municipal wastes. Alternatively, if a particular wastewater contains an identifiable major constituent that contributes to the BOD, use this compound in place of the glucose-glutamic acid.

Determine the 5-d 20°C BOD of a 2% dilution of the glucose-glutamic acid standard check solution using the techniques outlined in ¶s 4*d-j*. Evaluate data as described in ¶ 6, Precision and Bias.

d. Seeding:

1) Seed source—It is necessary to have present a population of microorganisms capable of oxidizing the biodegradable organic matter in the sample. Domestic wastewater, unchlorinated or otherwise-undisinfected effluents from biological waste treatment plants, and surface waters receiving wastewater discharges contain satisfactory microbial populations. Some samples do not contain a sufficient microbial population (for example, some untreated industrial wastes, disinfected wastes, high-temperature wastes, or wastes with extreme pH values). For such wastes seed the dilution water by adding a population of microorganisms. The preferred seed is effluent from a biological treatment system processing the waste. Where this is not available, use supernatant from domestic wastewater after settling at room temperature for at least 1 h but no longer than 36 h. When effluent from a biological treatment process is used, inhibition of nitrification is recommended.

Some samples may contain materials not degraded at normal rates by the microorganisms in settled domestic wastewater. Seed such samples with an adapted microbial population obtained from the undisinfected effluent of a biological process treating the waste. In the absence of such a facility, obtain seed from the receiving water below (preferably 3 to 8 km) the point of discharge. When such seed sources also are not available, develop an adapted seed in the laboratory by continuously aerating a sample of settled domestic wastewater and adding small daily increments of waste. Optionally use a soil suspension or activated sludge, or a commercial seed preparation to obtain the initial microbial population. Determine the existence of a satisfactory population by testing the performance of the seed in BOD tests on the sample. BOD values that increase with time of adaptation to a steady high value indicate successful seed adaptation.

2) Seed control—Determine BOD of the seeding material as for any other sample. This is the *seed control.* From the value of the seed control and a knowledge of the seeding material dilution (in the dilution water) determine seed DO uptake. Ideally, make dilutions of seed such that the largest quantity results in at least 50% DO depletion. A plot of DO depletion, in milligrams per liter, versus milliters seed should present a straight line for which the slope indicates DO depletion per milliliter of seed. The DO-axis intercept is oxygen depletion caused by the dilution water and should be less than 0.1 mg/L (¶ 4*h*). To determine a sample DO uptake subtract seed DO uptake from total DO uptake. The DO uptake of seeded dilution water should be between 0.6 and 1.0 mg/L.

Techniques for adding seeding material to dilution water are described for two sample dilution methods (¶ 4*f*).

e. Sample pretreatment:

1) Samples containing caustic alkalinity or acidity—Neutralize samples to pH 6.5 to 7.5 with a solution of sulfuric acid (H_2SO_4) or sodium hydroxide (NaOH) of such strength that the quantity of reagent does not dilute the sample by more than 0.5%. The pH of seeded dilution water should not be affected by the lowest sample dilution.

2) Samples containing residual chlorine compounds—If possible, avoid samples containing residual chlorine by sampling ahead of chlorination processes. If the sample has been chlorinated but no detectable chlorine residual is present, seed the dilution water. If residual chlorine is present, dechlorinate sample and seed the dilution water (¶ 4*f*). Do not test chlorinated/dechlorinated samples without seeding the dilution water. In some samples chlorine will dissipate within 1 to 2 h of standing in the light. This often occurs during sample transport and handling. For samples in which chlorine residual does not dissipate in a reasonably short time, destroy chlorine residual by adding Na_2SO_3 solution. Determine required volume of Na_2SO_3 solution on a 100- to 1000-mL portion of neutralized sample by adding 10 mL of 1 + 1 acetic acid or 1 + 50 H_2SO_4, 10 mL potassium iodide (KI) solution (10 g/100 mL), and titrating with Na_2SO_3 solution to the starch-iodine end point for residual. Add to neutralized sample the relative volume of Na_2SO_3 solution determined by the above test, mix, and after 10 to 20 min check sample for residual chlorine. (NOTE: Excess Na_2SO_3 exerts an oxygen demand and reacts slowly with certain organic chloramine compounds that may be present in chlorinated samples).

3) Samples containing other toxic substances—Certain industrial wastes, for example, plating wastes, contain toxic metals. Such samples often require special study and treatment.

4) Samples supersaturated with DO—Samples containing more than 9 mg DO/L at 20°C may be encountered in cold waters or in water where photosynthesis occurs. To prevent loss of oxygen during incubation of such samples, reduce DO to saturation at 20°C by bringing sample to about 20°C in partially filled bottle while agitating by vigorous shaking or by aerating with clean, filtered compressed air.

5) Sample temperature adjustment—Bring samples to 20 ± 1°C before making dilutions.

6) Nitrification inhibition—If nitrification inhibition is desired add 3 mg 2-chloro-6-(trichloro methyl) pyridine (TCMP) to each 300-mL bottle before capping or add sufficient amounts to the dilution water to make a final concentration of 10 mg/L. (NOTE: Pure TCMP may dissolve slowly and can float on top of the sample. Some commercial formulations dissolve more readily but are not 100% TCMP; adjust dosage accordingly.) Samples that may require nitrification inhibition include, but are not limited to, biologically treated effluents, samples seeded with biologically treated effluents, and river waters. Note the use of nitrogen inhibition in reporting results.

f. Dilution technique: Dilutions that result in a residual DO of at least 1 mg/L and a DO uptake of at least 2 mg/L after 5 d incubation produce the most reliable results. Make several dilutions of prepared sample to obtain DO uptake in this range. Experience with a particular sample will permit use of a smaller number of dilutions. A more rapid analysis, such as COD, may be correlated approximately with BOD and serve as a guide in selecting dilutions. In the absence of prior knowledge, use the following dilutions: 0.0 to 1.0% for strong industrial wastes, 1 to 5% for raw and settled wastewater, 5 to 25% for biologically treated effluent, and 25 to 100% for polluted river waters.

Prepare dilutions either in graduated cylinders and then transfer to BOD bottles or prepare directly in BOD bottles. Either dilution method can be combined with any DO measurement technique. The number of bottles to be prepared for each dilution depends on the DO technique and the number of replicates desired.

When using graduated cylinders to prepare dilutions, and when seeding is necessary, add seed either directly to dilution water or to individual cylinders before dilution. Seeding of individual cylinders avoids a declining ratio of seed to sample as increasing dilutions are made. When dilutions are prepared directly in BOD bottles and when seeding is necessary, add seed directly to dilution water or directly to the BOD bottles.

1) Dilutions prepared in graduated cylinders—If the azide modification of the titrimetric iodometric method (Section 4500-O.C) is used, carefully siphon dilution water, seeded if necessary, into a 1- to 2-L-capacity graduated cylinder. Fill cylinder half full without entraining air. Add desired quantity of carefully mixed sample and dilute to appropriate level with dilution water. Mix well with a plunger-type mixing rod; avoid entraining air. Siphon mixed dilution into two BOD bottles. Determine initial DO on one of these bottles. Stopper the second bottle tightly, water-seal, and incubate for 5 d at 20°C. If the membrane electrode method is used for DO measurement, siphon dilution mixture into one BOD bottle. Determine initial DO on this bottle and replace any displaced contents with sample dilution to fill the bottle. Stopper tightly, water-seal, and incubate for 5 d at 20°C.

2) Dilutions prepared directly in BOD bottles—Using a wide-tip volumetric pipet, add the desired sample volume to individual BOD bottles of known capacity. Add appropriate amounts of seed material to the individual BOD bottles or to the dilution water. Fill bottles with enough dilution water, seeded if necessary, so that insertion of stopper will displace all air, leaving no bubbles. For dilutions greater than 1:100 make a primary dilution in a graduated cylinder before making final dilution in the bottle. When using titrimetric iodometric methods for DO measurement, prepare two bottles at each dilution. Determine initial DO on one bottle. Stopper second bottle tightly, water-seal, and incubate for 5 d at 20°C. If the membrane electrode method is used for DO measurement, prepare only one BOD bottle for each dilution. Determine initial DO on this bottle and replace any displaced contents with dilution water to fill the bottle. Stopper tightly, water-seal, and incubate for 5 d at 20°C. Rinse DO electrode between determinations to prevent cross-contamination of samples.

g. Determination of initial DO: If the sample contains materials that react rapidly with DO, determine initial DO immediately after filling BOD bottle with diluted sample. If rapid initial DO uptake is insignificant, the time period between preparing dilution and measuring initial DO is not critical.

Use the azide modification of the iodometric method (Section 4500-O.C) or the membrane electrode method (Section 4500-O.G) to determine initial DO on all sample dilutions, dilution water blanks, and where appropriate, seed controls.

h. Dilution water blank: Use a dilution water blank as a rough check on quality of unseeded dilution water and cleanliness of incubation bottles. Together with each batch of samples incubate a bottle of unseeded dilution water. Determine initial and final DO as in ¶s 4*g* and *j*. The DO uptake should not be more than 0.2 mg/L and preferably not more than 0.1 mg/L.

i. Incubation: Incubate at 20°C ± 1°C BOD bottles containing desired dilutions, seed controls, dilution water blanks, and glucose-glutamic acid checks. Water-seal bottles as described in ¶ 4*f*.

j. Determination of final DO: After 5 d incubation determine DO in sample dilutions, blanks, and checks as in ¶ 4*g*.

5. Calculation

When dilution water is not seeded:

$$\text{BOD}_5\text{, mg/L} = \frac{D_1 - D_2}{P}$$

When dilution water is seeded:

$$\text{BOD}_5\text{, mg/L} = \frac{(D_1 - D_2) - (B_1 - B_2) f}{P}$$

where:

D_1 = DO of diluted sample immediately after preparation, mg/L,
D_2 = DO of diluted sample after 5 d incubation at 20°C, mg/L,
P = decimal volumetric fraction of sample used,
B_1 = DO of seed control before incubation, mg/L (¶ 4*d*),
B_2 = DO of seed control after incubation mg/L (¶ 4*d*), and
f = ratio of seed in diluted sample to seed in seed control = (% seed in diluted sample)/(% seed in seed control).

If seed material is added directly to sample or to seed control bottles:

f = (volume of seed in diluted sample)/(volume of seed in seed control)

Report results as CBOD$_5$ if nitrification is inhibited.

If more than one sample dilution meets the criteria of a residual DO of at least 1 mg/L and a DO depletion of at least 2 mg/L and there is no evidence of toxicity at higher sample concentrations or the existence of an obvious anomaly, average results in the acceptable range.

In these calculations, do not make corrections for DO uptake by the dilution water blank during incubation. This correction is unnecessary if dilution water meets the blank criteria stipulated above. If the dilution water does not meet these criteria, proper corrections are difficult and results become questionable.

6. Precision and Bias

There is no measurement for establishing bias of the BOD procedure. The glucose-glutamic acid check prescribed in ¶ 4*c* is intended to be a reference point for evaluation of dilution water quality, seed effectiveness, and analytical technique. Single-laboratory tests using a 300-mg/L mixed glucose-glutamic acid solution provided the following results:[1]

Number of months: 14
Number of triplicates: 421
Average monthly recovery: 204 mg/L
Average monthly standard deviation: 10.4 mg/L

In a series of interlaboratory studies,[2] each involving 2 to 112 laboratories (and as many analysts and seed sources), 5-d BOD measurements were made on synthetic water samples containing a 1:1 mixture of glucose and glutamic acid in the total concentration range of 3.3 to 231 mg/L. The regression equations for mean value, $\bar{X}$, and standard deviation, S, from these studies were:

$\bar{X}$ = 0.658 (added level, mg/L) + 0.280 mg/L
S = 0.100 (added level, mg/L) + 0.547 mg/L

For the 300-mg/L mixed primary standard, the average 5-d BOD would be 198 mg/L with a standard deviation of 30.5 mg/L.

a. Control limits: Because of many factors affecting BOD tests in multilaboratory studies and the resulting extreme variability in test results, one standard deviation, as determined by interlaboratory tests, is recommended as a control limit for individual laboratories. Alternatively, for each laboratory, establish its control limits by performing a minimum of 25 glucose-glutamic acid checks (¶ 4*c*) over a period of several weeks or months and calculating

5220 B. Open Reflux Method

1. General Discussion

a. Principle: Most types of organic matter are oxidized by a boiling mixture of chromic and sulfuric acids. A sample is refluxed in strongly acid solution with a known excess of potassium dichromate ($K_2Cr_2O_7$). After digestion, the remaining unreduced $K_2Cr_2O_7$ is titrated with ferrous ammonium sulfate to determine the amount of $K_2Cr_2O_7$ consumed and the oxidizable organic matter is calculated in terms of oxygen equivalent. Keep ratios of reagent weights, volumes, and strengths constant when sample volumes other than 50 mL are used. The standard 2-h reflux time may be reduced if it has been shown that a shorter period yields the same results.

2. Apparatus

Reflux apparatus, consisting of 500- or 250-mL erlenmeyer flasks with ground-glass 24/40 neck* and 300-mm jacket Liebig, West, or equivalent condenser† with 24/40 ground-glass joint, and a hot plate having sufficient power to produce at least 1.4 W/cm² of heating surface, or equivalent.

3. Reagents

a. Standard potassium dichromate solution, 0.0417*M:* Dissolve 12.259 g $K_2Cr_2O_7$, primary standard grade, previously dried at 103°C for 2 h, in distilled water and dilute to 1000 mL.

b. Sulfuric acid reagent: Add Ag_2SO_4, reagent or technical grade, crystals or powder, to conc H_2SO_4 at the rate of 5.5 g Ag_2SO_4/kg H_2SO_4. Let stand 1 to 2 d to dissolve Ag_2SO_4.

c. Ferroin indicator solution: Dissolve 1.485 g 1,10-phenanthroline monohydrate and 695 mg $FeSO_4 \cdot 7H_2O$ in distilled water and dilute to 100 mL. This indicator solution may be purchased already prepared.‡

d. Standard ferrous ammonium sulfate (FAS) titrant, approximately 0.25*M:* Dissolve 98 g $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ in distilled water. Add 20 mL conc H_2SO_4, cool, and dilute to 1000 mL. Standardize this solution daily against standard $K_2Cr_2O_7$ solution as follows:

Dilute 10.0 mL standard $K_2Cr_2O_7$ to about 100 mL. Add 30 mL conc H_2SO_4 and cool. Titrate with FAS titrant using 0.10 to 0.15 mL (2 to 3 drops) ferroin indicator.

$$\text{Molarity of FAS solution} = \frac{\text{Volume 0.0417}M\ K_2Cr_2O_7\ \text{solution titrated, mL}}{\text{Volume FAS used in titration, mL}} \times 0.25$$

e. Mercuric sulfate, $HgSO_4$, crystals or powder.

f. Sulfamic acid: Required only if the interference of nitrites is to be eliminated (see 5220A.2 above).

g. Potassium hydrogen phthalate (KHP) standard: Lightly crush and then dry potassium hydrogen phthalate ($HOOCC_6H_4COOK$) to constant weight at 120°C. Dissolve 425 mg in distilled water and dilute to 1000 mL. KHP has a theoretical COD[1] of 1.176 mg O_2/mg and this solution has a theoretical COD of 500 µg O_2/mL. This solution is stable when refrigerated for up to 3 months in the absence of visible biological growth.

4. Procedure

a. Treatment of samples with COD of > 50 mg O_2/L: Place 50.0 mL sample (for samples with COD of > 900 mg O_2/L, use smaller sample portion diluted to 50.0 mL) in a 500-mL refluxing flask. Add 1 g $HgSO_4$, several glass beads, and very slowly add 5.0 mL sulfuric acid reagent, with mix-

*Corning 5000 or equivalent.
†Corning 2360, 91548, or equivalent.
‡GFS Chemical Co., Columbus, Ohio.

ing to dissolve $HgSO_4$. Cool while mixing to avoid possible loss of volatile materials. Add 25.0 mL 0.0417*M* $K_2Cr_2O_7$ solution and mix. Attach flask to condenser and turn on cooling water. Add remaining sulfuric acid reagent (70 mL) through open end of condenser. Continue swirling and mixing while adding the sulfuric acid reagent. CAUTION: *Mix reflux mixture thoroughly before applying heat to prevent local heating of flask bottom and a possible blow-out of flask contents.*

Cover open end of condenser with a small beaker to prevent foreign material from entering refluxing mixture and reflux for 2 h. Cool and wash down condenser with distilled water. Disconnect reflux condenser and dilute mixture to about twice its volume with distilled water. Cool to room temperature and titrate excess $K_2Cr_2O_7$ with FAS, using 0.10 to 0.15 mL (2 to 3 drops) ferroin indicator. Although the quantity of ferroin indicator is not critical, use the same volume for all titrations. Take as the end point of the titration the first sharp color change from blue-green to reddish brown. The blue-green may reappear. In the same manner, reflux and titrate a blank containing the reagents and a volume of distilled water equal to that of sample.

b. Alternate procedure for low-COD samples: Follow procedure of ¶ 4*a*, with two exceptions: (*i*) use standard 0.00417*M* $K_2Cr_2O_7$, and (*ii*) titrate with 0.025*M* FAS. Exercise extreme care with this procedure because even a trace of organic matter on the glassware or from the atmosphere may cause gross errors. If a further increase in sensitivity is required, concentrate a larger volume of sample before digesting under reflux as follows: Add all reagents to a sample larger than 50 mL and reduce total volume to 150 mL by boiling in the refluxing flask open to the atmosphere without the condenser attached. Compute amount of $HgSO_4$ to be added (before concentration) on the basis of a weight ratio of 10:1, $HgSO_4:Cl^-$, using the amount of Cl^- present in the original volume of sample. Carry a blank reagent through the same procedure. This technique has the advantage of concentrating the sample without significant losses of easily digested volatile materials. Hard-to-digest volatile materials such as volatile acids are lost, but an improvement is gained over ordinary evaporative concentration methods.

c. Determination of standard solution: Evaluate the technique and quality of reagents by conducting the test on a standard potassium hydrogen phthalate solution.

5. Calculation

$$\text{COD as mg } O_2/L = \frac{(A - B) \times M \times 8000}{\text{mL sample}}$$

where:

A = mL FAS used for blank,
B = mL FAS used for sample, and
M = molarity of FAS.

6. Precision and Bias

A set of synthetic samples containing potassium hydrogen phthalate and NaCl was tested by 74 laboratories. At a COD of 200 mg O_2/L in the absence of chloride, the standard deviation was ±13 mg/L (coefficient of variation, 6.5%). At COD of 160 mg O_2/L and 100 mg Cl^-/L, the standard deviation was ±14 mg/L (coefficient of variation, 10.8%).

7. Reference

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AOCS Official Method G 5-40

Reapproved 1997

Neutral Oil

DEFINITION

This method determines the total neutral oil, i.e., unsaponified oil in the sample. Any unsaponifiable fatty matter in the sample will be included.

SCOPE

Applicable to all types of soapstock.

APPARATUS

1. Cylinder—250 mL, glass-stoppered.
2. Separatory funnel—500 mL.
3. Beaker—400 mL, or Soxhlet flask, 500 mL.

REAGENTS

1. Aqueous potassium hydroxide (KOH)—14% KOH by weight (see Notes, *Caution*).
2. Ethyl alcohol—SDA Formulas 30 and 3A are permitted, 50% by volume. Mix 10 volumes of 95% alcohol with 9 volumes of distilled water.
3. Ethyl alcohol—as above, 10% by volume. Mix 2 volumes of 95% alcohol with 17 volumes of distilled water.
4. Petroleum ether—AOCS Specification H 2-41 (see Notes, *Caution*).

PROCEDURE

1. Mix the sample thoroughly and weigh immediately.
2. Weigh 8–10 g of the sample (4–5 g acidulated soapstock) into an extraction cylinder. Add 125 mL of 50% alcohol, 50 mL of petroleum ether and shake until a homogeneous mixture is formed.
3. Cool to 20–25°C and add 10 mL of the aqueous KOH (Reagents, 1). Agitate gently until thoroughly mixed, but avoid vigorous shaking.
4. Add 25 mL of 50% ethyl alcohol and agitate gently until thoroughly mixed. Allow to settle until the two layers are completely separated, but do not allow the ether/oil layer to remain in contact with the alcohol/alkali layer longer than 30 min.
5. Siphon the ether/oil layer into a 500-mL separatory funnel. Make at least four more similar extractions using 50 mL of petroleum ether for each extraction. Combine all of the extracts in the separatory funnel.
6. Wash the ether extract in the separatory funnel with 25-mL portions of 10% alcohol, shaking vigorously each time, until the washings are neutral to phenolphthalein. Three washings are usually sufficient. Filter through filter paper and wash the paper free from fatty matter with petroleum ether.
7. Draw the ether extract into a tared beaker or Soxhlet flask which has been previously dried and cooled in a desiccator. Evaporate the ether in a water bath under a gentle stream of clean, dry nitrogen. Dry in an air oven at 105 ± 2°C for 30 min. Cool in a desiccator to ambient temperature and weigh. Repeat until constant weight is attained. A constant weight is attained when the loss (or gain) in weight does not exceed 0.1% in successive 30-min drying periods.

CALCULATION

$$\text{Neutral Oil, \%} = \frac{\text{mass of neutral oil}}{\text{mass of sample, g}} \times 100$$

NOTES

Caution

When working with extremely caustic materials like sodium or potassium hydroxide, always add pellets to water and not the reverse. Alkalies are extremely exothermic when mixed with water. Take precautions to contain the caustic solution in the event the mixing container breaks from the extreme heat generated.

Petroleum ether is extremely flammable. Avoid static electricity. The explosive limits in air are 1–6%. A fume hood should be used at all times when using petroleum ether.