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Prevalence of Goitre among Population, Shendi Locality, River Nile State, 2013

A thesis submitted in fulfilment of the requirement for the degree of PhD in public health

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الآية

قال تعالى:

(وعلم أدم الأسماء كلها ثم عرضهم على الملائكة

فقال أنبئوني بأسماء هؤلاء إن كنتم صدقين)

صدق الله العظيم

سورة البقرة31

Dedication

To my parents whom awarded

me a sense of life

To my small family, my life

(wife &daughter)

To my brothers whom pave to me

the way

I dedicate this study with much

love And best wishes to all.

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I would like to start by thanking GOD for his help during all the conduction of this work, as a little part of his generous help throughout my life.

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Abstract

The study was conducted as a community based descriptive Cross – sectional study to assess prevalence of goitre among population in Shendi locality, River Nile State, Sudan, during the period 2011-2013. This is the first assessment for the prevalence of goitre in Shendi locality. In this study 636 households were included .Questionnaire and observation were used as tools for data collection. The households were selected through a multistage cluster-sampling technique to determine the prevalence of goitre, 636 respondent were selected through systemic random sampling. I found that The overall prevalence of goitre was 18% amongst the population surveyed. The highest prevalence of 5.3% goitre was observed in Hajer-Alasal administration, while the lowest prevalence of 3.6% goitre was recorded in Shendi town. The study found that the knowledge and awareness among the general population about goiter disease is high (63%), (60%) of population have no knowledge about iodized salt, and the study found that Goiter was more prevalent among age group (31-45) which represent (43,5%) of person who has goiter. Also high prevalence among female than male with a ratio of 3:1.

Finally, the study recommends that, the ministry heath should take action through intervention strategies, like extensive nutrition, and health education to strength iodine supplementation programm and the role of national and non-governmental organization. The university of Shendi should participate through work shops , lecture , and health programs to aware the population about the importance of iodine and hazardous of it's deficiency.

مستخلص الدراسة

أجري الباحث هذه الدراسة الوصفية المقطعية في مجتمع محلية شندي لدراسة إنتشار تضخم الغدة الدرقية لدي مجتمع محلية شندي بولاية نهر النيل في الفترة من 2011- 2013م . وهذه أول دراسة تجري لمعرفة إنتشار تضخم الغدة الدرقية بمحلية شندي. شملت هذه الدراسة 636 منزل. تم إستخدام الإستبيان والملاحظة كوسائل لجمع البيانات، استخدمت الطريقة العنقودية لتحديد نسبة الإنتشار. وتم توزيع الإستبيان علي 636 شخص بالطريقة العشوائية البسيطة المنتظمة.

أظهرت الدراسة أن إنتشار تضخم الغدة الدرقية الكلي بالمحلية بلغ 18% لدي المجتمع، أعلي نسبة إنتشار لوحظت في إدارية حجر العسل حيث بلغت 5.3% ، بينما أقلاها سجلت في إدارية مدينة شندي 3.6%.

الدراسة توصلت علي أن أكثر من نصف المجتمع 63% لديهم معرفة بتضخم الغدة الدرقية وأن 60% ليس لدهم معرفة بالملح الميودن، كما أوضحت الدراسة أن إنتشار تضخم الغدة الدرقية أكثر شيوعا في الفئة العمرية (31-45سنة) حيث مثلت 43.5% من الأشخاص المصابين، وقد مثلت النساء أعلي نسبة من الرجال بنسبة 1:3.

ختاما فإن الدراسة توصي وزارة الصحة بإتخاذ القرارات اللازمة مثل إستراتيجيات التدخل ، البرامج التغذوية والتثقيف الصحي لدعم مشكلة تضخم الغدة الدرقية ببرامج محددة لتقوية وزيادة عنصر اليود، وتعزز من دور المنظمات الوطنية وغير الحكومية العاملة في مجال التغذية. كما أوصت الدراسة جامعة شندي بالقيام بدورها تجاه المجتمع والإهتمام بمشاكله الصحية من خلال المشاركة عبر ورش العمل والمحاضرات والبرامج الصحية المختلفة حتى تزيد من وعي المجتمع بأهمية عنصر اليود والمخاطر التي تنتج عن نقصه.

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Abbreviation	*Meaning*
IDD	Iodine Deficiency Disorder
IQ	Intelligence Quotient
WHA	World Health Assembly
UNICEF	United Nations Children's Fund
KAN	Kazakhstan Academy of Nutrition
IS	Iodized Salt
PHC	Primary Health Care
CE	Capillary Electrophoresis
IC	Ion Chromatography
HPLC	High-Performance Liquid Chromatography
GC	Gas Chromatography
AES	Atomic Emission Spectrometry
NAA	Neutron Activation Analysis
USA	United State of America
WHO	World Health Organization
TPO	Thyroid peroxidase
DIT	Di Iodo Tyrosine
TRH	Thyroid Releasing Hormone
TSH	Thyroid Stimulating Hormone
RDA	Recommended Dietary Allowance
TGR	Total Goiter Rate
ICCIDD	International Council for the Control of Iodine Deficiency Disorders
IIH	Iodine-Induced Hyperthyroidism

NHMRC	National Health and Medical Research Council
USI	Universal salt iodization
NIDDCP	National Iodine Deficiency Disorders Control Programme
MPHW	Multi Purpose Health Workers
DHO	Digital Humanities Observatory
DSMO	Designed Standard Maintenance Organization
IEC	Information, education and communication
NGOs	Non Governmental Organizations
NCCIDD	National Committee for Control of IDD
HDPE	High Density Poly Ethylene.
PP	Poly Propylene
MCH	Maternal and Child Health
FAO	Food and Agriculture Organization
EPI	Expanded Program of Immunization
CI	Confidence Interval
PPS	Probability Proportional to Size'
SPSS	Statistical Package for Social Sciences
WFP	World Food Programm
UK	United Kingdom
TG	Thyro-Globulin
MIT	Mono-Iodo-Thyrosine
STK	Spot Testing Kits.
UIC	Urine Iodine Concentration

1. Introduction

Iodine, the Greek word for violet, was first isolated as a violet vapor during the making of gunpowder at the end of the 18th century. Most iodine exists in the ocean: sea water, fish and vegetables. It was present during the primordial development of the earth, and large amounts were leached from the surface soil by glaciation, snow or rain and carried by wind, rivers and floods into the sea. Iodine is found in the deep layers of soil and in oil wells and natural gas effluents. Water from such deep wells can be a major source for iodine. But the return of iodine to soil has been slow and small in amount compared to the original loss; subsequent repeated flooding ensures that iodine deficiency in the soil continues. There is no natural rectification and iodine deficiency persists indefinitely in the soil. All crops grown in these soils are iodine deficient. As a result, human and animal populations, which are totally dependent on food grown in such soil, become iodine deficient. This accounts for the occurrence of severe iodine deficiency in vast populations worldwide, especially those dependent on food grown in iodine deficient soil. Iodine deficiency is today recognized as the most common preventable cause of mental defects in the world. It is estimated that 1.6 billion people in 130 countries are at risk of iodine deficiency disorders. Iodine deficiency can result in abortions, stillbirths, motor skill disturbances, impaired growth, impaired cognitive developments, mental defects, deaf-mutism, spastic weakness, paralysis and affects child learning capacity (lower IQ), women's health, the quality of life of communities and economic productivity. Yet iodine deficiency disorders (IDD) can be prevented by the inexpensive, cost effective method of salt iodization, the most effective measure for their control. (Hetzel, 2004).

Recognizing the importance of IDD prevention, the World Health Assembly (WHA), in 1991, adopted the goal of eliminating iodine deficiency as a public health problem by the year 2000. In 1990, world leaders had endorsed this goal when they met at the World Summit for Children at the United Nations. It was reaffirmed by the International Conference on Nutrition in 1992. In 1993, WHO and UNICEF recommended universal salt iodization (USI) as the main strategy to achieve elimination of IDD.

Attempts to improve iodine nutrition in areas of iodine deficiency have been made using iodine supplementation through iodination of bread, water, sugar, oil etc.

Although these routes of supplementation have been successful in some regions and communities, it appears that salt iodization is the simplest, cheapest and most effective means of providing optimum iodine nutrition. Iodized oil preparations may be used when iodized salt is not widely available. (Azizi, 2007)

Since 1990, there has been tremendous progress in increasing the amount and availability of adequately iodized salt. As a result, many countries are now on the threshold of achieving IDD elimination. In those countries, the emphasis will shift to ensuring that the achievements are sustained for all time. However, in some countries of the world, iodine supplementation has not been implemented and in many countries, iodine nutrition is defective and cannot reach the recommended levels of daily consumption. Therefore, in 2005, WHA passed another resolution once again encouraging member states to strive for the elimination of iodine deficiency. (WHO, 2007)

2 Problem statement:

Iodine deficiency disorders (IDD) is a public problem affecting more than 740 million people throughout the world. Iodine deficiency disorders (IDDs) are one of the worldwide public health problems of today. Their effect is hidden and profound affecting quality of life. Globally 2.2 billion people live in areas with iodine deficiency and risk its complications2. In India, 167 million people are at risk of iodine deficiency disorders, 54.4 million people have goitre and 8.8 million people have IDD related mental/motor handicaps. It is a major public health problem in 211 of 245 districts surveyed.

In the Sudan, the period from the early 1980s to the mid 1990s witnessed substantial activity in connection with iodine deficiency disorders (IDDs) in the form of epidemiological and etiological studies and assessments of the effects of different interventions. The total prevalence of goitre reported in those studies ranged from 13% in the eastern city of Port Sudan and 17% in Khartoum state, to 78% in the central region and 87% in Darfur, in the west. According to a national study conducted in 1997, the overall prevalence of all types of goitre was 22% and prevalence figures ranged from 5% in the city of Khartoum to 42% in the Upper Nile region. It has been estimated that every year more than 200 000 children born in the Sudan are at risk of iodine deficiency and that 3% of those children may develop cretinism, while 10% may experience severe intellectual impairment and 87% less severe intellectual disability. (Bani, 2007)

3. Justification:

To our knowledge there was no such an intervention study has been done in Shendi locality and there is no previous survey about the subject.

The professional public health worker has the challenge and responsibility to help population gain the knowledge, attitudes and practice of iodine dietary necessary for prevention of goiter.

Part of the mission of the Shendi University towards community in the area, and participate in their problems solving.

4 Objectives:

4.1General objective:

- To study the prevalence of goitre and knowledge, attitude and practice of iodized salt among population in Shendi locality River Nile State.

4.2 Specific objective:

- To determine the prevalence of goitre in Shendi locality.
- To identify the environmental and socio-economic factors which predispose to goitre in the study area.
- To determine the knowledge of population about goitre.
- To determine the knowledge and practice of population towards iodized salt.
- To identify the most affected Age groups and gender.
- To investigate on the local nutritional factors that may contribute to the incidence of goitre in Shendi.

2. Literature Review

2.1 Background :

2.1.1 Prevalence of goiter in the world:

Prevalence of goiters among school-aged children in the Markakol and Katon-Karagay areas in the East-Kazakhstan oblast (region) varies from 12% up to 35%, and the general prevalence of goiters among schoolchildren in Kentau city in the South-Kazakhstan oblast (region) is equal to 26%. In these regions, up to 50-60% of the adult population has clinical signs of the goiter.(Haar, 2005).

The Kazakhstan Academy of Nutrition (KAN) for the first time, within the framework of the National Demographic and Health Survey of Kazakhstan, carried out a study of the median level of UIC in women of childbearing age, and surveyed 5844 households for a background survey of iodized salt (IS) consumption. Only 29% of these households consumed iodized salt (IS). Among 2979 households surveyed in the south and east regions of Kazakhstan, where the situation with the endemic goiter is the most severe, the consumption of iodized salt (IS) was 21.6% and 24.5% respectively. (Haar, 2005).

Among women of childbearing age in the south and east regions of Kazakhstan the percentage of women with a low level of UIC was 52% and 67% respectively. In the north region of the republic this parameter was 60.7% and in the west region, which was considered as not being severely affected by IDD, it was 61.0%. Only in the Central region it was at the lower level of 25%.(Haar, 2005).

According to a previous survey among 4800 respondents only 58.6% were aware of the necessity of regular consumption of iodized table salt and 42% deliberately bought this salt (F.E. Ospanova, 2000).

In 2001-2002, with the technical support of UNICEF in Kazakhstan the national survey of "Knowledge, Attitude and Practices" concerning IDD elimination was conducted in 2001-2002 with UNICEF support. The study indicated that the level of knowledge and awareness among the general population about IDD and the strategy for its elimination was rather low. Of rural schoolchildren, 70% had no knowledge of IDD or its biological consequences. Only 33% of urban and 24% of rural children were aware that IDD could be prevented by the use of iodized salt, although almost 70% had heard of iodized salt. Only 20% of adults knew that iodized salt is necessary to alleviate IDD, and among those who did use iodized salt in their households, as many as 44% did not know why iodized salt is a necessity. (Haar, 2005).

The survey identified health workers as an important traditional source of information. Among primary health care workers, however, only 22% were confident that IDD could be alleviated by the use of iodized salt, while one-third were convinced that the human body could produce iodine by itself. Significantly, 61% of Primary Health Care (PHC) workers recalled having been asked by their clients for advice on the need for using iodized salt. (Haar, 2005).

2.1.2 Iodine deficiency disorders in Africa:

Iodine deficiency is a major public health problem throughout Africa and is the commonest cause of thyroid disorders in this continent. Iodine deficiency is defined as a median urinary iodine concentration less than 50 μg/L in a population. Internationally, 2.2 billion people worldwide are at risk for iodine deficiency disorder. Of these persons, 30-70% have goiter and 1-10% have cretinism. .(Taga, *etal*, 2008).

The UNICEF estimates state that 8% of newborns from sub-Saharan Africa are unprotected from learning disabilities resulting from iodine deficiency related disorders. In children and adolescents, the range of iodine deficiency disorders include goiter, sub clinical hypothyroidism, impaired mental function, retarded physical development, and increased susceptibility of the thyroid gland to nuclear radiation. In adults, IDD include goiter with its complications, hypothyroidism, impaired mental function, spontaneous hyperthyroidism in the elderly, iodine-induced hyperthyroidism, and increased susceptibility of the thyroid gland to nuclear radiation. .(Taga, *etal*, 2008).

Endemic goiter, characterized by enlargement of the thyroid gland in a significantly large fraction of a population group (in a population when >5% of 6-12-year-old children have enlarged thyroid glands) is a notable feature of iodine deficiency. It is pertinent to note that although there is a demonstrable association between iodine deficiency and endemic goiter, goitrogens (substances that suppress the function of the thyroid gland by interfering with iodine uptake) may also play a role in the development of endemic goiter. In Africa, goitrogens of note include thiocyanates that are often found in poorly detoxified cassava, a staple food that is commonly eaten as a source of carbohydrate. Selenium deficiency has also been reported to be a contributory factor in the occurrence of endemic goiter in Africa or persistence of endemic goiter in iodine deficient areas even after correcting for iodine deficiency In a Cameroun report, the prevalence of thiocyanate overload and iodine deficiency was 20% and 21%, respectively . Endemic goiters are seen in both mountainous (New Guinea) and nonmountainous regions of Africa (Cameroun, Northern Zaire, Central Africa Republic, Uganda, and Rwanda). The prevalence rates of endemic goiters in Africa range from 1% to 90% .(Taga, *etal*, 2008).

Other manifestations of iodine deficiency that include endemic cretinism and development of hyperthyroidism in multinodular goiter are not as widely studied as the endemic goiters in the African continent. Endemic cretinism occurs in areas of severe iodine deficiency and is manifested by two major clinical patterns- the myxedematous form which is the commonly occurring form of cretinism in Africa and the neurological form. The prevalence rates of endemic cretinism range from 1.2% to 6% with Central Africa recording the highest rate. It is interesting to note that there are hardly reports on endemic cretinism in the twenty-first century Africa and this may be largely due to widespread iodization programs in the continent. Although there is no objective evidence to conclude that endemic cretinism has been totally eradicated in the continent, it is safe to postulate that this IDD may not be as prevalent as it use to be in this part of the world.(Anthonia, 2011).

2.1.3 Endemic goiter in Sudan:

In the Sudan, the period from the early 1980s to the mid 1990s witnessed substantial activity in connection with iodine deficiency disorders (IDDs) in the form of epidemiological and etiological studies and assessments of the effects of different interventions. The total prevalence of goiter reported in those studies ranged from 13% in the eastern city of Port Sudan and 17% in Khartoum state, to 78% in the central region and 87% in

Darfur, in the west. According to a national study conducted in 1997, the overall prevalence of all types of goitre was 22% and prevalence figures ranged from 5% in the city of Khartoum to 42% in the Upper Nile region. It has been estimated that every year more than 200 000 children born in the Sudan are at risk of iodine deficiency and that 3% of those children may develop cretinism, while 10% may experience severe intellectual impairment and 87% less severe intellectual disability. (Bani, 2007)

Various etiological factors in addition to iodine deficiency contribute to goiter endemicity in the Sudan. They include vitamin A deficiency and protein-energy malnutrition, both of which can affect thyroid function, and the very high consumption of pearl millet, which contains thiocyanate, a goitrogenic substance.(Abdel Monim, *etal*, 2011)

Although IDD control programmes in the form of distribution of iodized oil capsules and iodized sugar and the universal salt iodization strategy, were launched in the Sudan as early as the mid 1970s, in 2006, when this study was conducted, no progress in implementation had been made. (Bani, 2007).

Indeed, most iodine supplementation programmes, if not all, had ceased to exist, and only 1% of all Sudanese households had access to iodized salt, according to estimates by the United Nations Children's Fund (UNICEF).(Hussein, 2006).

A more recent situational analysis has shown that IDDs still affect children and women throughout the Sudan and that no policy supporting universal salt iodization is in place.(Izzeldin, 2009).

2.1.4 Sudan launches universal salt iodization:

An IDD Control Program was initiated in Sudan in 1989 using iodized oil capsules and this program continues in highly endemic regions of the country. In 1994 Sudan adopted salt iodization as the long-term strategy to control IDD, but there was no order or decree prohibiting the sale of non-iodized salt. A recent household survey reported iodized salt coverage was only 9.3%. The National Nutrition Directorate under the Federal Ministry of Health is the lead government agency responsible for monitoring the salt iodization program in Sudan. (ICCIDD, 2012)

2.1.5 Salt production in Sudan

Salt is produced mainly in the Red Sea State where >95% of Sudanese salt is made by solar evaporation of Red Sea brine. Small quantities of rock salt is produced at Jabal Marra in western Sudan. Based on per capita consumption, Sudan needs about 140,000 tons of salt per year for edible use. Other requirements include about 30,000 tons of salt for production of caustic lye and 15,000 tons for other non-edible uses. Thus, the total annual requirements are about 185,000 tons. No salt is imported and salt produced in Sudan is exported to Ethiopia, Chad, and the Central African Republic. In Port Sudan there are 17 salt manufacturing units, of which two are in the government sector. Two major producers in the private sector account for ca. 130,000 tons of production. (ICCIDD, 2012)

2.1.6 A new initiative

A major new initiative of ICCIDD, with funding from CIDA, plans to increase national awareness of IDD in Sudan at all levels. It will support the USI program in Sudan, define the steps needed to improve coverage of iodized salt and set up a rigorous quality control and monitoring system. The specific objectives are to conduct advocacy meetings and national level workshops; train the salt industry and develop a training manual for sustainable salt iodization and capacity building; conduct a situation analysis and identify the challenges and major constraints for universal iodization in Sudan; establish a robust QC/QA system with training of laboratory personnel; and, finally, establish a national multi-sectoral body to oversee implementation of the program and steer policy.

The ICCIDD team in Sudan, in close collaboration with Sudanese Federal Ministry of Health, is made up of the ICCIDD Regional Coordinator, Dr Izzeldin Hussein, a senior quality control and laboratory expert, Dr Husain Al Jawarnah, and the renowned Professor Mohamed A. El-Tom, the ICCIDD national focal point in Sudan. Their main partners from Sudan are the salt industry, the Director of Primary Health Care, the Director General of Industry and the Director of the National Nutrition Program, as well as representatives from the UNICEF, WFP, MI and WHO offices in Sudan. (ICCIDD, 2012)

2.1.7 Legislation on USI enforcement:

As a first step, ICCIDD contributed to the drafting of comprehensive salt iodization legislation in 2010 with the Ministry of Health, the National Nutrition Program and other regulatory bodies in the country.

The legal provisions on monitoring covered two aspects. First, self-monitoring by the salt industry defined procedures for internal monitoring, where the industry routinely examines its own processes and procedures to identify and correct problems found. Second, external monitoring is legislated by the government pursuant to its inspection and investigation powers. However, until 2012 the implementation of the law had not been formally approval and this remained a major obstacle. (ICCIDD, 2012)

2.1.8 Launching USI:

Therefore, the next step in Sudan was the launching of the new legislation and the national program on USI, a long-awaited event including all stakeholders. In an upbeat and festive ceremony sponsored by ICCIDD, the launch took place in the Red Sea State in June 2012 and was attended by more than 15 federal and state ministers, governors, head of localities and legislative authorities, director generals of various government departments, directors of the police and army, the directorate of measurement and specification and the school health and nutrition department leaders. Attendees included representatives of salt retailers and wholesalers, salt producers, health insurers, as well as representatives of UN agencies in Sudan, the humanitarian aid agencies, and FAO. Also participating were pediatrician and children's organizations, representatives from preventive medicine, pharmacology and laboratories, as well as artists and media representatives. (ICCIDD, 2012)

The ceremony included a moving carnival that started from the Ministry of Health and toured the city, then moved to the governor's office and on to the exhibition site where the salt iodization plants are operated. The Health Minister and other stakeholders inaugurated the exhibition, and the launching program included speeches from the governor, ICCIDD, WFP, UNICEF. The new salt legislation was read to the public by the chair of the legislative council and officially brought into force. (ICCIDD, 2012)

2.1.9 The future:

The launching resulted in a consensus statement on actions needed and principles to follow to accelerate the progress towards USI. ICCIDD and the Nutrition Directorate in Khartoum agreed to draw up a Plan of Action for the 5-year period 2012-2017. The plan aims to increase the knowledge and awareness of the population, increase coverage of iodized salt to 90% of the population, and conduct a national survey to track progress after the introduction of iodized salt. It includes social marketing, social mobilization and training of USI monitors across the country to establish a proper surveillance system. To ensure sustainability, ICCIDD coordinated the formation of the Sudan national IDD coalition and will support their efforts to increase coverage of the population with adequately iodized salt. It will also continue to advocate at high levels to ensure continuing governmental interest in enforcing salt iodization to improve national health and economic development. (ICCIDD, 2012)

Goiter prevalence in Elfigaiga village (south to Shendi town) was found to be (11,9%), which is considered as endemic goiter, because it is grater than the endemicity limit (more than 10%). (Elamin, 1998).

The prevalence of all types of goiter was found to be 38.8% overall and ranged from 12.2% in Omdurman to 77.7% in Kosti city.(Abdel Monim, et al, 2011)

The over all prevalence of goiter was estimated by Aisha Ishag which was (49%) (274 goiterous and 276 of them nongoiterous) of them (43,6%) males and (56,4%) females.

Fashashoia and Attawilla have statistically significant higher number of goiterous subject compared with other study areas. The prevalence of goiter decreased from north to south.(Aisha, 2004).

Iodine is an essential component of the thyroid hormones that play an important role in human development, growth, and metabolism, especially of the brain. Iodine deficiency in humans can cause several diseases or problems, which include spontaneous abortion, increased infant mortality, cretinism, goiter, and mental defects. Seawater is a huge reservoir of iodine. One of the major pathways for the entry of iodine into the human food chain involves the transfer of iodine from the sea to the atmosphere, its subsequent deposition onto soil and incorporation into plants and animals. Kelp, a type of macro algae in the ocean, is a rich source of iodine and is thus used as a food and nutritional supplement. Iodine in seaweeds is mainly iodide, with a very small fraction of iodine present as iodate and organoiodine in the form of monoiodotyrosine and diiodotyrosine. Marine algae are also used as natural sources of iodine in the feeding of freshwater fish, which on consumption would improve the iodine intake of man. Generally, iodine is extracted from seaweeds or seawater, and added to edible salt to supplement the intake of iodine for people who live in iodine deficient areas.

Iodine in seawater can also have an impact on the global biogeochemical cycle of iodine, affecting the supply of iodine to the atmosphere from the oceans. Iodine atoms are involved in atmospheric ozone depletion and aerosol formation reactions in the marine boundary layer, and hence have an influence on the earth's radiative balance and weather, which in turn may affect human health (Li, *et al.*, 2009).

Iodine is ubiquitous in seawater having a total dissolved concentration of about 400–500 nmol· in most places, where it exists mainly as iodide and iodate along with a small fraction of organic iodine compounds. The distribution of iodide and iodate in seawater varies with depth and geographical location. The thermodynamically stable form of iodine in seawater is iodate, which is the dominant form in most of the oceans. Iodide in the oceans is produced by biologically mediated reduction of iodate, also favorable under reducing conditions. Up to 50% of the dissolved inorganic iodine may be present as iodide in surface seawater. Organic iodine constitutes less than 5% of the dissolved iodine in the open ocean, but a large fraction (40–80%) of the dissolved iodine may be present in an organic form in estuarine and coastal waters (Li, *et al.* 2009).

The determination of iodine in seawater helps in understanding the marine environment. A variety of analytical methods have been proposed for the quantitative determination of iodine in seawater. This chapter discusses the methods employed for the separation and determination of iodine in seawater. These methods include capillary electrophoresis (CE), ion chromatography (IC), high-performance liquid chromatography (HPLC), gas chromatography (GC), spectrophotometry, ion-selective electrode, polarography, voltammetry, atomic emission spectrometry (AES), and neutron activation analysis (NAA). The advantages and limitations of these methods are also assessed and discussed. Since iodine is present in the ocean at trace levels and the matrices of seawater are complex, especially in estuarine and coastal waters, the methods developed for the determination of iodine in seawater are usually of high sensitivity and selectivity. Thus, these methods could also be used for the determination of iodine in other samples, such as food, blood, and urine samples, either directly or with minor modifications. (Li, *et al*, 2009).

2.2 Ecology:

Iodine (atomic weight 126.9 g/atom) is an essential component of the hormones produced by the thyroid gland. Thyroid hormones, and therefore iodine, are essential for mammalian life. Iodine (as iodide) is widely but unevenly distributed in the earth's environment. Most iodide is found in the oceans (≈50 μg/L), and iodide ions in seawater are oxidized to elemental iodine, which volatilizes into the atmosphere and is returned to the soil by rain, completing the cycle. However, iodine cycling in many regions is slow and incomplete, and soils and ground water become deficient in iodine. Crops grown in these soils will be low in iodine, and humans and animals consuming food grown in these soils become iodine deficient (WHO, 2007). In plant foods grown in deficient soils, iodine concentration may be as low as 10 μg/kg dry weight, compared to ≈1 mg/kg in plants from iodine-sufficient soils. Iodine deficient soils are most common in inland regions, mountainous areas and areas of frequent flooding, but can also occur in coastal regions (Assey, et al, 2006). This arises from the distant past through glaciation, compounded by the leaching effects of snow, water and heavy rainfall, which removes iodine from the soil. The mountainous regions of Europe, the Northern Indian Subcontinent, the extensive mountain ranges of China, the Andean region in South America and the lesser ranges of Africa are all iodine deficient. Also, the Ganges Valley in India, the Irrawaddy Valley in Burma, and the Songkala valley in Northern China are also areas of endemic iodine deficiency. Iodine deficiency in populations residing in these areas will persist until iodine enters the food chain through addition of iodine to foods (e.g. iodization of salt) or dietary diversification introduces foods produced in iodine-sufficient areas. (Creswell, 2009).

2.3 Physiology and Requirements:

Iodine is classified as a nonmetallic solid in the halogen family of the Periodic Table of the elements and therefore is related to fluorine, chlorine, and bromine.

The halogen family lies between the oxygen family and the rare gases. Iodine sublimates at room temperature to form a violet gas; its name is derived from the Greek iodes, meaning ‘violet-colored.’ Iodine was discovered by Bernard Courtois in Paris in 1811, the second halogen (after chlorine) to be discovered. It took nearly 100 years to understand its critical importance in human physiology. In 1896, Baumann determined the association of iodine with the thyroid gland, and in 1914 Kendall, with revisions by Harrington in 1926, described the hormone complexes synthesized by the thyroid gland using iodine that are so integral to human growth and development.(Houston, 2009)

As the biochemistry of iodine and the thyroid was being established, the scarcity of the element in the natural environment became evident and the link between deficiency and human disease was revealed.

Enlargement of the thyroid, or goitre, is seen in ancient stone carvings and Renaissance paintings, but it was not until years later that the link with lack of iodine was firmly established. Even with this knowledge, many years passed before preventive measures were established. From 1910 to 1920 in Switzerland and the USA work was done on the use of salt fortified with iodine to eliminate iodine deficiency, with classic work being done by Dr DavidMarine in Michigan. Recently the linkage of iodine deficiency with intellectual impairment has brought iodine into the international spotlight. . (Houston, 2009)

Recent work has demonstrated that the halogens, including iodine, are involved through the halo peroxidases in enzymatic activity and production of numerous active metabolites in the human body. While the importance of iodine for the thyroid has been known for some time, recent research on halogen compounds in living organisms suggests additional more complex roles including antibiotic and anticancer activity. Yet it is the critical importance of iodine in the formation of the thyroid hormones thyroxine (T4) and triiodothyronine (T3) that makes any discussion of this element and human physiology of necessity bound up with a review of thyroid function. (Houston, 2009)

2.4 Existence of Iodine in the Natural Environment

The marine hydrosphere has high concentrations of halogens, with iodine being the least common and chlorine the most. Halogens, including iodine, are concentrated by various species of marine organisms such as macroalgae and certain seaweeds. Release from these organisms makes a major contribution to the atmospheric concentration of the halogens.

Iodine is present as the least abundant halogen in the Earth's crust. It is likely that in primordial times the concentration in surface soils was higher, but today the iodine content of soils varies and most has been leached out in areas of high rainfall or by previous glaciation. Environmental degradation caused by massive deforestation and soil erosion is accelerating this process. This variability in soil and water iodine concentration is quite marked, with some valleys in China having relatively high iodine concentrations in water, and other parts of China with negligible amounts in soil and water. Table 1 shows the relative abundance of various halogens in the natural environment, while Figure 1 illustrates the cycle of iodine in nature. . (Houston, 2009)

Commercial production of iodine occurs almost exclusively in Japan and Chile, with iodine extracted from concentrated salt brine from underground wells, seaweed, or from Chilean saltpetre deposits. .(Houston, 2009)

2.5 Absorption, Transport, and Storage

Iodine is usually ingested as an iodide or iodate compound and is rapidly absorbed in the intestine. Iodine entering the circulation is actively trapped by the thyroid gland. This remarkable capacity to concentrate iodine is a reflection of the fact that the most critical physiological role for iodine is the normal functioning of the thyroid gland. Circulating iodide enters the capillaries within the thyroid and is rapidly transported into follicular cells and on into the lumen of the follicle. This active transport is likely to be based on cotransport of sodium and iodine, allowing iodine to move against its electrochemical gradient. (Houston, 2009)

Several anions, such as thiocyanate, perchlorate, and pertechnetate, inhibit this active transport. There is evidence that the active transport clearly demonstrated in the thyroid gland is also true for extrathyroidaltissues, including the salivary glands, mammary glands, and gastric mucosa. .(Houston, 2009)

In addition to trapping iodine, follicular cells also synthesize the glycoprotein, thyroglobulin (Tg), from carbohydrates and amino acids (including tyrosine) obtained from the circulation. Thyroglobulin moves into the lumen of the follicle where it becomes available for hormone production. Thyroid peroxidase (TPO), a membrane-bound hem-containing glycoprotein, catalyzes the oxidation of the iodide to its active form, I2, and the binding of this active form to the tyrosine in thyroglobulin to form mono- or diiodotyrosine (MIT or DIT). These in turn combine to form the thyroid hormones triiodothyronine (T3) and thyroxine (T4). Thyroglobulin is very concentrated in the follicles through a process of compaction, making the concentration of iodine in the thyroid gland very high. Only a very small proportion of the iodine remains as inorganic iodide, although even for this unbound iodide the concentration in the thyroid remains much greater than that in the circulation. This remarkable ability of the thyroid to concentrate and store iodine allows the gland to be very rapidly responsive to metabolic needs for thyroid hormones. .(Houston, 2009)

Formation of thyroid hormones is not restricted to humans. Marine algae have an 'iodine pump' that facilitates concentration; invertebrates and all vertebrates demonstrate similar mechanisms to concentrate iodine and form iodotyrosines of various types.

Although the function of these hormones in invertebrates is not clear, in vertebrates these iodinecontaining substances are important for a variety of functions, such as metamorphosis in amphibians, spawning changes in fish, and general translation of genetic messages for protein synthesis. . (Houston, 2009)

Table 1 Relative abundance of halogens in the natural environment

Element	Abundance in oceans (ppm)	Abundance in Earth's crust (ppm)	Abundance in human body (mol)
Flourine	1,3	625	0,13
Chlorine	19400	130	2,7
Bromine	67	2,5	0,0033
Iodine	0,06	0,05	0,00013

2.6 Dietary sources of iodine:

The native iodine content of most foods and beverages is low, and most commonly consumed foods provide 3 to 80 μg per serving (Thomson, et al, 2008). Major dietary sources of iodine in the USA, Europe and Australia are bread, milk and to a lesser extent seafood (Haldimann, et al, 2005). Based on direct food analysis, mean intake of dietary iodine is ≈140 μg/day in Switzerland and 100-180 μg/day in Libya. Boiling, baking, and canning of foods containing iodised salt cause only small losses (≤10%) of iodine. Iodine content in foods is also influenced by iodine-containing compounds used in irrigation, fertilizers, and livestock feed. Iodophors, used for cleaning milk cans and teats in the dairy industry, can increase the native iodine content of dairy products through contamination of iodine containing residues, there are few data on the bioavailability of iodine or potential health risks from these iodophors. Replaced by non-iodine-containing conditioners. Recommendations for daily iodine intake by age group are shown in Table 2.

Table 2: Recommendations for iodine intake (µg/day) by age or population group, (Creswell, 2009).

Age or population Group	U.S. Institute of Medicine (ref.5)	Age or population Groups	World Health Organization (ref.1)
Infant 0-12 months	110-130	Children 0-5 years	90
Children 1-8 years	90	Children 6-12	120
Children 9-13 years	120		
Adults ≥14 years	150	Adults > 12 years	150
Pregnancy	220	Pregnancy	250
Lactation	290	Lactation	250

2.7 Iodine in the environment:

Iodine is present at the Earth’s surface in very small amounts and is what geochemists refer to as a trace element. A feature of iodine geochemistry that distinguishes it from other trace elements is its mobility in the surface environment. This characteristic makes it a critical component of radioactive waste management, because radioactive iodine is a by-product of the nuclear industry and there is concern over environmental contamination.

Much of our recent knowledge of iodine's geochemical behavior comes from migration studies of iodine radioisotopes. (Jonhson,2003).

Seawater is a major source of iodine in the geochemical cycle with average concentrations of around 58 μg/l iodine . Iodate (IO_3^-) is the most stable form of iodine in seawater and this is reduced to iodide (I^-) in surface waters mediated by biological activity. Seaweeds and phytoplankton release iodine containing organic gases (e.g. CH_3I and CH_2I_2) that pass into the atmosphere and are subject to further chemical changes by the action of sunlight. Iodine in the atmosphere migrates inland and is deposited in wet or dry precipitation as a result of the prevailing climatological and topographical conditions. As a result, coastal zones inevitably tend to be the most iodine-enriched environments. Studies of iodine in soils, crops and surface waters have shown a general decline in iodine levels away from the seacoast, although this is not a simple linear correlation. In surface soils located 0–50 km from the sea, for example, high but variable levels of iodine are found . This is in contrast to inland soils where uniformly low levels of iodine predominate. Iodine can be re-volatilized from the soil-plant interface, also probably involving biological conversion of iodine to organic forms. It will migrate further away from the coast until precipitated again on the land. (Jonhson,2003).

The weathering of rocks is also a source of iodine in the surface environment. Organic-rich shales, for example, can average as much as 20 μg/g I. However, such rocks in terms of overall global distribution are rare and the Earth's continental crust is dominated by rocks averaging only 0.2 μg/g I and contributing relatively little iodine to surface soils. In terms of iodine deficiency disorders, it is the pathways from soil-plant-man and water-man that are of the most importance and iodine in soil, drinking waters and crops will be described in more detail here. (Jonhson,2003)..

2.7.1 Iodine in soil

The iodine status of a soil is a combination of the supply of iodine and the soil's ability to retain it. A soil from a coastal zone may have a high input of iodine but if it cannot hold on to the iodine then it will remain deficient. The iodine fixation potential of a soil is a complex mixture of many factors that include the soil's organic content, the soil texture, the chemical form of the iodine, and the prevailing oxidation and acidity conditions (Eh/pH). (Jonhson,2003)..

The average iodine content for soils from the project's database (2151 results of screened data from all over the world) is 5.1 µg/g. However, given the skewed nature of the data distribution, the geometric mean of 3.0 µg/g is a more suitable value to quote for the level of iodine in soils. Research into iodine residence time in soils suggests that they equilibriate with the environment's levels relatively rapidly and it is unlikely that glacial soils from recent ice ages (10 000 years ago) are 'under saturated' with iodine. (Jonhson,2003).

Organic matter plays an important role in fixing iodine in the soil and peats tend to be the most iodine-enriched of all soils.

Contrary to what might be expected, organic-rich soils, whilst high in iodine, are not good providers of the element to the food chain because it is strongly fixed and not bioavailable. Any consideration relating the status of an environment to the iodine status of the population needs to look at the soil's bioavailable and not total iodine. Generally less than 10% of the soil's iodine can be extracted with cold water and this is a good indication of how much is bioavailability. (Jonhson,2003)..

Iodide is the most mobile form of iodine in the soil and is more readily taken up by plants than iodate. Acidic soil conditions favour iodide whilst alkaline oxidising conditions (such as that found in dry thin soils of limestone areas) favour the less soluble iodate form. There is no need to invoke the presence of goitrogens in limestone areas that are noted for their high prevalence of IDD. Simple Eh/pH considerations would suggest the iodine in alkaline environments is less mobile. (Jonhson,2003)..

2.7.2 Iodine in drinking water:

Surface waters are probably the best index of an environment's iodine status, although iodine deficiency disorders do occur in areas where water iodine levels are relatively high. Iodine in water represents the mobile form of the element (hence bioavailable) and waters are more easily analyzed than soils and vegetation. Early work in the USA and UK suggests a threshold level of 3 μg/l below which an environment could be defined as iodine deficient. There is a wide range of results reported for the iodine (Jonhson,2003).

Content of drinking water from <0.1 to 150 μg/l, an average for all results being 4.4 μg/l. Those studies that have looked at drinking waters from a number of sources suggest artesian or deep water well supplies are most enriched in iodine. The general level of iodine reported in natural surface waters (rivers and lakes) ranges from 1–10 μg/l.

Drinking water generally provides about ten percent of the Recommended Dietary Allowance (RDA) which is 150 μg per day for iodine. However, in regions dependent on the local environment for food, and without adventitious or iodine supplementation, drinking water can provide more than twenty percent of the daily iodine intake. (Jonhson,2003)..

2.7.3 Iodine in foodstuffs:

There is no evidence to suggest that iodine fulfils any role in terrestrial plants and there is no apparent correlation between the amount of total iodine in the soil and the content of crops. However, excessive iodine in the soil can be toxic to plants and this is illustrated by the occurrence in rice of 'Reclamation Akagare' disease, a physiological disorder caused by flooding paddy fields on iodine-rich soils.

Arable crops generally contain less than 50 μg/kg (fresh weight) iodine in the order legumes >vegetables > fruit. If a major pathway for iodine into the plant system is through leaf adsorption, then leafy vegetables must be considered to have an advantage in concentrating iodine. The iodine content of plants is seen to increase with the proportion of leaves. Iodine is not mobile in plants and is not concentrated in the seed. Processing the seed for food consumption is likely to decrease the iodine content further. Therefore, grain crops such as rice and wheat cannot therefore be considered as good providers of the element. (Jonhson,2003).

Grazing animals and their products are richer sources of iodine, they act as concentrators of the element by grazing large areas of pasture on which iodine has been precipitated from the atmosphere. (Jonhson,2003).

The levels of iodine in milk, eggs and meat are further raised by adventitious sources added during food production. This is iodine introduced to the food for reasons other than supplementation. For example, iodine levels in milk are high, because of the use of ionospheres as antiseptic cleansing agents in milk production. In developed countries, cow's milk is the major contributor to dietary iodine exposure and, for example, in the UK in 1995 was calculated to contribute 42% of the total intake. In the UK current levels of iodine in milk are of the order of 300 μg/kg although this is subject to seasonal variations. However, seafood is the most enriched source of iodine in the diet with levels in fish averaging 1000–2000 μg/kg (fresh weight) which is some forty times richer in iodine than most other foodstuffs. (Jonhson,2003).

2.8 Iodine deficiency:

Iodine Deficiency Disorders (IDD) have multiple and serious adverse effects including cretinism, goiter, impaired cognitive function, impaired growth, infant mortality, and stillbirths in a large proportion of the world's population. The degree of impairment in function is related to the severity of iodine deficiency. Even marginal degrees of iodine deficiency have a measurable impact on human development. There has been great progress in prevention and treatment of IDD in the last decade.

The obvious need for interventions probably explains why there have been relatively few randomized, placebo-controlled trials of the efficacy of iodine supplementation on different aspects of human function. The most commonly used indicators are: enlarged thyroid volume: prevalence of goitre, or total goitre rate (TGR); enlarged thyroid gland; urinary iodine; and elevated neonatal serum levels of thyroid stimulating hormone (TSH). Iodine deficiency is defined as endemic when it affects more than 10% of the population. (WHO, 2001)

Iodine Deficiency Disorders (IDD) refers to all of the ill effects of iodine deficiency in a population that can be prevented by ensuring that the population has an adequate intake of iodine. Iodine deficiency at critical stages during pregnancy and early childhood results in impaired development of the brain and consequently in impaired mental function. (WHO, 2001)

2.8.1 Ecology of Iodine Deficiency:

There is a cycle of iodine in nature. Most of the iodine resides in the ocean. It was present during the primordial development of the earth, but large amounts were leached from the surface soil by glaciation, snow, or rain and were carried by wind, rivers, and floods into the sea. Iodine occurs in the deeper layers of the soil and is found in oil well and natural gas effluents, which are now a major source for the production of iodine.

The better known areas that are leached are the mountainous areas of the world. The most severely deficient soils are those of the European Alps, the Himalayas, the Andes, and the vast mountains of China. However, iodine deficiency is likely to occur to some extent in all elevated regions subject to glaciation and higher rainfall, with runoff into rivers. It has become clear that iodine deficiency also occurs in flooded river valleys, such as the Ganges in India, the Mekong in Vietnam, and the great river valleys of China.

Iodine occurs in soil and the sea as iodide. Iodide ions are oxidized by sunlight to elemental iodine, which is volatile so that every year approximately 400,000 tons of iodine escapes from the surface of the sea. The concentration of iodide in the seawater is approximately 50–60 mg/l, and in the air it is approximately 0.7 mg/m3. The iodine in the atmosphere is returned to the soil by rain, which has a concentration of 1.8–8.5 mg/l. In this way, the cycle is completed (Figure 1).

However, the return of iodine is slow and the amount is small compared to the original loss of iodine, and subsequent repeated flooding ensures the continuity of iodine deficiency in the soil. Hence, no natural correction can take place and iodine deficiency persists in the soil indefinitely. All crops grown in these soils will be iodine deficient. The iodine content of plants grown in iodine-deficient soils may be as low as 10 mg/kg compared to 1mg/kg dry weight in plants in a non-iodine-deficient soil.

As a result, human and animal populations that are totally dependent on food grown in such soil become iodine deficient. This accounts for the occurrence of severe iodine deficiency in vast populations in Asia that live within systems of subsistence agriculture in flooded river valleys (India, Bangladesh, Burma, Vietnam, and China). (Hetzel, et al, 2009)

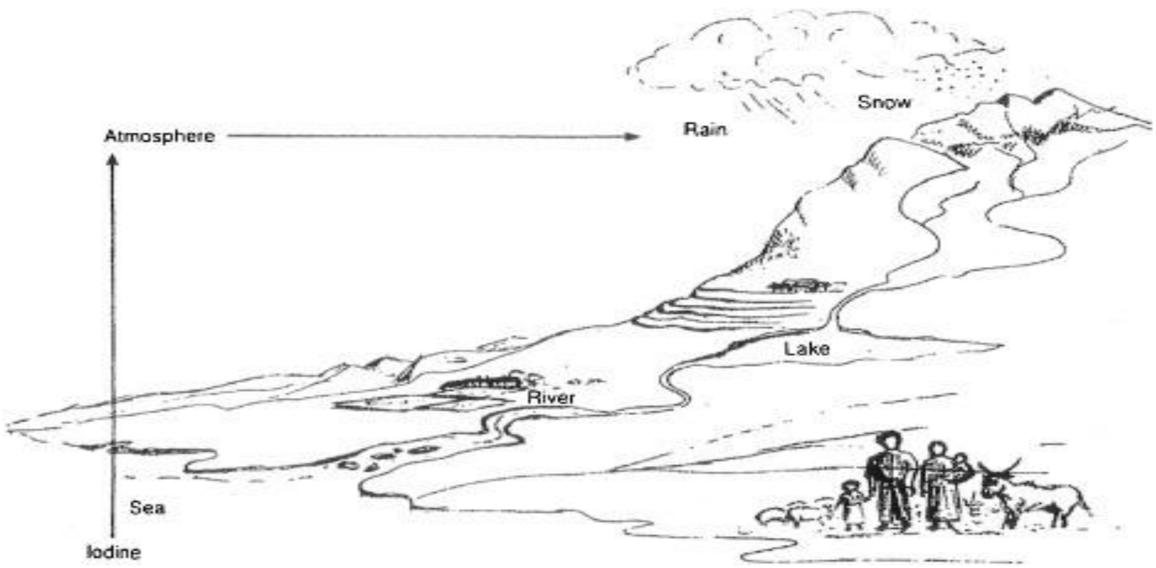

Figure 1 The iodine cycle in nature. The atmosphere absorbs iodine from the sea, which then returns through rain and snow to mountainous regions. It is then carried by rivers to the lower hills and plains, eventually returning to the sea. High rainfall, snow, and flooding increase the loss of soil iodine, which has often been already denuded by past glaciation. This causes the low iodine content of food for man and animals.

2.8.2 Causes of Iodine Deficiency

The main cause of iodine deficiency in soils is leaching by glaciation, floods or high rainfall. Mountainous regions including the Andes and the Himalayas therefore have some of the highest prevalences of iodine deficiency. Iodine deficiency also occurs due to flooding; for example, in Bangladesh and in India around the Ganges. In areas of endemic iodine deficiency, the water and foods (plants and animals grown there) have low iodine content. (Preventing and Treating Iodine Deficiency (2001)

Many staple foods consumed in developing countries contain cyanogenic glucosides that can liberate cyanide. Cyanide is converted to thiocyanate in the body. , This is a goitrogen, as it blocks the uptake of iodine by the thyroid. With the exception of cassava, cyanogenic glucosides are located in the inedible portion of plants. Cassava, however, must be soaked before consumption to remove the goitrogens. Consumption of cassava was associated with endemic goitre and cretinism in Sarawak, Malaysia371. The adverse effects can also be overcome by increasing iodine intake. Preventing and Treating Iodine Deficiency (2001)

2.8.3 The importance of iodine deficiency disorders (IDD):

Iodine deficiency, through its effects on the developing brain, has condemned millions of people to a life of few prospects and continued underdevelopment. On a worldwide basis, iodine deficiency is the single most important preventable cause of brain damage. IDD are among the easiest and cheapest of all disorders to prevent. A small, constant amount of iodine to the salt every day is all that is needed.(WHO,2000).

We all face a danger if our diet lacks iodine and the consequence is a number of medical conditions grouped under the general heading of iodine deficiency disorders (IDD). Only a trace amount of iodine is required, as little as 100–150 μg is the recommended daily dose, less than three grammes of iodine during the course of a lifetime. Cretinism, mental retardation, decreased fertility, increased perinatal death and infant mortality will result from instances of severe iodine deficiency.

An understanding of the role of iodine in endemic goitre was the first recognized association between a trace element in the environment and human health. Treatment of goitre using iodine rich seaweed has been used for thousands of years though it was not until the early 1900's that the need for iodine in the diet (specifically for its thyroid function) was recognized. (Jonhson,2003).

The main thrust of effort to reduce the risks from iodine deficiency disorders is coordinated by the International Council for the Control of Iodine Deficiency Disorders (ICCIDD). This is *'a non-profit, non-government organization for the sustainable elimination of iodine deficiency and the promotion of optimal iodine nutrition worldwide'.* Much of the effort in eliminating IDD centres on the use of medical prophylaxes and proceeds relatively successfully without a sound understanding of its principal cause, a deficiency of iodine in the environment. There is a perceived need for a better understanding of the geochemistry of iodine so we can ensure that the small environmental amounts available are used in the most efficient way. Hence, where iodine is added directly to the environment by methods such as dripping into irrigation water we will be better able to ensure that it reaches the food chain. (Johnson, 2003)

The aim of this project has been to look at factors controlling the bioavailability of iodine in the Earth's surface and suggest environmental solutions to reduce the risks from IDD by supplementing medical intervention schemes where necessary. The output from the work is specifically aimed at informing the medical community about the geochemical behaviour of iodine in the environment.

The project uses data gathered from two case studies in China and Morocco and a comprehensive bibliography covering iodine geochemistry.

Information from these sources has been interpreted to give us a clearer understanding of the behaviour of iodine in the surface environment. Strategies for more efficient use of environmental iodine are proposed, along with a summary of environmental intervention schemes that have been employed by other researchers. (Johnson, 2003)

2.9 Iodine Deficiency Disorders:

The effects of iodine deficiency on the growth and development of a population that can be prevented by correction of iodine deficiency, denoted by the term IDD, are evident at all stages, including particularly the fetus, the neonate, and in infancy, which are periods of rapid brain growth. The term goiter has been used for many years to describe the enlarged thyroid gland caused by iodine deficiency. Goiter is indeed the obvious and familiar feature of iodine deficiency, but knowledge of the effects of iodine deficiency on brain development has greatly expanded in the past 30 years so that the term IDD was introduced to refer to all the effects of iodine deficiency on growth and development, particularly brain development, in a population that can be prevented by correction of the deficiency.

The following sections discuss in detail the IDD at various stages of life: the fetus, the neonate, the child and adolescent, and the adult. (Hetzel, et al, 2009).

Table: 3 Spectrums of Iodine Deficiency Disorders

Stages of life	**Iodine Deficiency Disorders**
Fetus	Abortions Stillbirths Congenital anomalies Neurological cretinism Mental deficiency, deaf mutism, spastic diplegia, squint Hypothyroid cretinism Mental deficiency, dwarfism, hypothyroidism Psychomotor defects
Neonate	Increased perinatal mortality Neonatal hypothyroidism Retarded mental and physical Development
Child and adolescent	Increased infant mortality Retarded mental and physical Development
Adult	Goiter with its complications Iodine-induced hyperthyroidism
All ages	Goiter Hypothyroidism Impaired mental function Increased susceptibility to nuclear radiation

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2.10 Definition of goiter:

A goiter is simply a thyroid gland that has grown to an abnormally large size. Some patients with goiter have a thyroid gland that is making too little thyroid hormone. An example of this would be Hashimoto's thyroiditis. Other patients with an abnormally large thyroid may have a gland that is overactive. For instance, patients with Graves' disease usually have an enlarged thyroid. However, many people have a goiter and yet have perfectly normal thyroid hormone levels in their blood. The thyroid is enlarged but it is making a normal amount of thyroid hormone.(Thomas, 2009)

The term “goiter” simply refers to the abnormal enlargement of the thyroid gland. It is important to know that the presence of a goiter does not necessarily mean that the thyroid gland is malfunctioning. A goiter can occur in a gland that is producing too much hormone (hyperthyroidism), too little hormone (hypothyroidism), or the correct amount of hormone (euthyroidism). A goiter indicates there is a condition present which is causing the thyroid to grow abnormally. .(Thomas, 2009)

A low amount of triiodiothyronine (T_3, one of the two thyroid hormones) in the blood, due to lack of dietary iodine to make it, should (but doesn't always) give rise to high levels of thyroid stimulating hormone TSH, which stimulates the thyroid gland to increase many biochemical processes; the cellular growth and proliferation can result in the characteristic swelling or hyperplasia of the thyroid gland, or goiter. The introduction of iodized salt since the early 1900s has eliminated this condition in many affluent countries; however, in Australia, New Zealand, and several European countries, iodine deficiency is a significant public health problem.[4] It is more common in third-world nations. Public health initiatives to lower the risk of cardiovascular disease have resulted in lower discretionary salt use at the table, and with a trend towards consuming more processed foods. The non-iodized salt used in these foods also means that people are less likely to obtain iodine from adding salt during cooking. . (Thomas, 2009)

Goiter is said to be endemic when the prevalence in a population is > 5%, and in most cases goiter can be treated with iodine supplementation. If goiter is untreated for around five years, however, iodine supplementation or thyroxin treatment may not reduce the size of the thyroid gland because the thyroid is permanently damaged. (Thomas, 2009)

Certain areas of the world, due to natural deficiency and governmental inaction, are severely affected by iodine deficiency, which affects approximately two billion people worldwide. It is particularly common in Western Pacific, South-East Asia and Africa. India is the most outstanding, with 500 million suffering from deficiency, 54 million from goiter, and two million from cretinism, (Herald. 2008).

Iodine deficiency has largely been confined to the developing world for several generations, but reductions in salt consumption and changes in dairy processing practices eliminating the use of iodine-based disinfectants have led to increasing prevalence of the condition in Australia and New Zealand in recent years. A proposal to mandate the use of iodized salt in most commercial bread making is expected to be adopted in 2009. (Howick, 2008).

2.10.1 Etiology:

Diffuse thyroid enlargement most commonly results from prolonged stimulation by TSH (or a TSH-like agent). Such stimulation may be the result of one of the causes of hypothyroidism (e.g. TSH in Hashimoto's thyroiditis) or of hyperthyroidism. Alternatively, goiter may occur in a clinically euthyroid patient.

Iodine deficiency is the most common cause of goiter in developing nations. A diet that contains less than 10 µg/d of iodine hinders the synthesis of thyroid hormone, resulting in an elevated TSH level and thyroid hypertrophy. Iodination of salt has eliminated this problem in much of the developed world. (Stephen, 2006).

A goiter may also develop from ingestion of goitrogens (factors that block thyroid hormone synthesis) either in food or in medication. Dietary goitrogens are found in vegetables of the Brassicaceae family (eg, rutabagas, cabbage, turnips, cassava). A goitrogenic hydrocarbon has been found in the water supply in some locations. Medications that act as goitrogens include thioamides and thiocyanates (eg, propylthiouracil, methimazole, nitroprusside), sulfonylureas, and lithium. Lithium inhibits thyroid hormone release and perhaps also iodide organification. Most patients remain clinically euthyroid because TSH production increases. (Stephen, 2006).

2.10.2 The causes of goiter:

Lack of iodine in the diet is the majority cause of endemic goiter, where the loss of iodine from the soil due to glaciating, erosion, high rain fall, snow and flooding leads to a low iodine content of all food grown in it. The husbandry and agriculture production was also lack of iodine content, which will be in appropriate resources when people in that area consumed it. Inadequate dietary iodine leads to reduce synthetics of thyroid hormones (T3 and T4). While the lower level of T4 in the blood stimulates the pituitary gland to secrete Thyrotrophin Stimulating Hormone (TSH) from the blood to fulfill the production of thyroid gland hormones. In other word, TSH increases the rate of pumping iodine by the thyroid from the blood, followed with hyperplasia of the thyroid gland, as resulted as goiter. Enlargement is regarded as significant in the human when the size of lateral lobes is greater than terminal phalanx of the thumb of the person examined. (Kurniawan, 2005)

Thyroid enlargement whether as form of a single small nodule or massive enlargement is typically symptoms of goiter, which occasionally accompanied with breathing and swallowing difficulties, cause of the compression of the trachea and esophagus. Neck vein distention and dizziness are occurred when the size of the thyroid gland rose above the head (large goiter). Chronic severe iodine deficiency is associated with thyroid hyperplasia. The prevalence of goiter increased, with the severity of the iodine deficiency and becomes almost universal in a population when the iodine intake less than 10 μg per day. (Kurniawan, 2005)

Iodine in the food stuff is widely available in seafood, such as “tenggiri” (cod) sejenis “ikan sungai” (sea bass), nama “ikan laut” (haddock) and ikan “air tawar berduri” (perch). Kelp or “lumut laut” is the most vegetable seafood that is a rich source of iodine. Dairy product and plants grown soil that is rich in iodine are also a good sources of iodine. The risk factors to become goiters are female, people older than forty, having an adequate dietary intakes, which living in an endemic area and having a family history of goiter.(Kurniawan, 2005)

2.11 Iodine deficiency disorders and their control, and global progress in their elimination:

2.11.1 iodine deficiency disorders:

Iodine deficiency occurs when iodine intake falls below recommended levels. It is a natural ecological phenomenon that occurs in many parts of the world. The erosion of soils inriverine areas due to loss of vegetation from clearing for agricultural production, overgrazing by livestock, and tree-cutting for firewood results in a continued and increasing loss of iodine from the soil. Groundwater and foods grown locally in these areas lack iodine.

When iodine intake falls below recommended levels, the thyroid may no longer be able to synthesize sufficient amounts of thyroid hormone. The resulting low level of thyroid hormones in the blood (hypothyroidism) is the principal factor responsible for damage to the developing brain and other harmful effects known collectively as “iodine deficiency disorders” The adoption of this term emphasizes that the problem extends far beyond simply goitre and cretinism.

The most critical period is from the second trimester of pregnancy to the third year after birth . Normal levels of thyroid hormones are required for optimal development of the brain. In areas of iodine deficiency, where thyroid hormone levels are low, brain development is impaired. In its most extreme form, this results in cretinism, but of much greater public health importance are the more subtle degrees of brain damage and reduced cognitive capacity which affects the entire population. As a result, the mental ability of ostensibly normal children and adults living in areas of iodine deficiency is reduced compared to what it would be otherwise. (Delange, 2000)

Thus, the potential of a whole community is reduced by iodine deficiency. Where the deficiency is severe, there is little chance of achievement and underdevelopment is perpetuated. Indeed, in an iodine-deficient population, everybody may seem to be slow and rather sleepy. The quality of life is poor, ambition is blunted, and the community becomes trapped in a self-perpetuating cycle. Even the domestic animals, such as village dogs, are affected. Livestock productivity is also dramatically reduced (Delange, 2000).

2.11.2 Identification of the occurrence of IDD:

In the past, the likely occurrence of iodine deficiency in a given region was regarded as being signalled by certain geographical characteristics. These include mountain ranges and alluvial plains, particularly at high altitude and at considerable distance from the sea. This occurrence was confirmed by a high prevalence of goitre in the resident population.

However, the greater use of urinary iodine estimation and other methods for assessing iodine deficiency has demonstrated that IDD can and does occur in many areas where none of these conditions are met. Indeed, significant iodine deficiency has been found:

• Where the prevalence of goitre is low and doesn't suggest a problem In coastal areas;

• In large cities;

• In highly developed countries;

• Where iodine deficiency has been considered to have been eliminated.

In recognition of a much wider occurrence of IDD than previously thought, certain countries have come to regard the whole country as being at risk of iodine deficiency and therefore the entire population as a target for IDD control with iodized salt. The need for continued vigilance is underlined, as is the importance of all countries carrying out periodic urinary iodine surveys. (Delange, 2000)

2.11.3 Correction of iodine deficiency

2.11.3.1 Administrative arrangements

The national body responsible for the management of the IDD control programme should operate with a process model. A useful example of such a process model is known as the "wheel.

This cycle, which is described in details following, shows the different elements of national IDD control. The successful achievement of this overall process requires the establishment of a national IDD control commission, with the ability to influence the political and legislative process. Several elements included within this model reflect programmatic needs that will determine the sustainability of the programme into the future. The model involves six components, clockwise in the hub of the wheel. Delange, 2000)

1. Assessment and periodic evaluation of the situation requires prevalence surveys of iodine status, including measurement of urinary iodine levels and an analysis of the salt situation. Most countries have completed this step, and now need to do periodic reassessment.
2. Dissemination of findings implies communication to health professionals and the public, so that there is full understanding of the IDD problem, the importance of using iodized salt and the potential benefits of iodine deficiency elimination. This needs to be an ongoing activity.
3. Planning: Development of a plan of action includes the establishment of an intersectoral task force on IDD including the salt industry and the formulation of a strategy document on achieving the elimination of IDD. The task force will need to remain active to ensure programme sustainability.
4. Achieving political will requires intensive education and lobbying of politicians and other opinion leaders on an ongoing basis. Delange, 2000)

5. Implementation needs the full involvement of the salt industry. Special measures, such as negotiations for monitoring and quality control of imported iodized salt, are required. It is also necessary to ensure that iodized salt delivery systems reach all affected populations, including those in greatest need. In addition, the establishment of cooperatives for small producers, or restructuring to larger units of production, may be needed. Implementation requires training at all levels in management, salt technology, laboratory methods, and communication.

6. Monitoring and evaluation require the establishment of an efficient system for the ongoing and routine collection of relevant data, including measures of salt iodine quality assurance and household use, and measures of programme performance.

The multidisciplinary orientation required for a successful programme poses special difficulties in implementation. Experience indicates that particular problems often arise between health professionals and the salt industry – with their different professional orientations. There is need for mutual education about the health and development consequences of iodine deficiency, and about the problems encountered by the salt industry in the continued production of high quality iodized salt. Such teamwork is required in order to achieve sustainability.

2.11.4 Universal salt iodization (USI)

In 1994, a special session of the WHO and UNICEF Joint Committee on Health Policy recommended USI as a safe, cost-effective, and sustainable strategy to ensure sufficient intake of iodine by all individuals . In nearly all countries where iodine deficiency occurs, it is now well recognized that the most effective way to achieve the virtual elimination of IDD is through USI.

USI involves the iodization of all human and livestock salt, including salt used in the food industry. Adequate iodization of all salt will deliver iodine in the required quantities to the population on a continuous and self-sustaining basis.

The additional cost of iodine fortification in the process of salt production should eventually be borne by the consumer, but is negligible. This will greatly assist sustainability. National salt iodization programmes are now implemented worldwide and have followed a common pattern of evolution, which includes the following phases:

• **Decision phase:** This phase involves making the decision for USI supported by industry, backed by standards and regulation, and supported by an implementation plan.

• **Implementation phase:** This phase ensures the infrastructure for iodization and packaging of all human and livestock salt, and supports that infrastructure with quality assurance measures, communication and demand creation, regulation, and enforcement.

• **Consolidation phase:** Once the goal of USI is achieved, it needs to be sustained and assessed through ongoing process and impact monitoring, as well as periodic evaluation; the latter may include international multidisciplinary teams. A successful salt iodization programme depends upon the implementation of a set of activities at the national level by various sectors:

• Government ministries (legislative and justice, health, industry, agriculture, education, communication, and finance);

• Salt producers, salt importers and distributors, food manufacturers;

• Concerned civic groups, including consumer associations; and

• Nutrition, food, and medical scientists, and other key opinion makers.

Opening the channels of communication and maintaining commitment and cooperation across these various groups is perhaps the greatest challenge to reaching the IDD elimination goal and sustaining it for the long term.

Salt producers and distributors are critical in ensuring that IDD is eliminated. Protecting consumers requires that a framework be established to ensure quality control of the production of iodized salt, as well as the distribution of adequately packaged and labelled iodized salt. The establishment of this framework is the main responsibility of the government.

Ensuring a demand for the product and understanding the reason for insisting upon only iodized salt is a shared responsibility of the private sector and government. Establishment of iodization as the norm and ensuring customer demand will determine the success and sustainability of the programme. USI, which ensures that all salt for human and animal consumption is adequately iodized, has been remarkably successful in many countries.

Over 30 countries have achieved the goal of USI (>90% of households using iodized salt), and many others are on track. Most countries that have failed to achieve coverage over 20% have confl ict situations that hinder all health efforts. In rare instances, it may happen that salt iodization efforts are unable to meet the requirement of women during pregnancy, exposing the progeny to potential developmental risks. In such situations, while efforts to improve the salt iodization programme continue, iodine supplementation may be considered for both pregnant women and children less than two years of age as a daily oral dose of iodine or a single oral dose of iodized oil every six to 12 months (WHO, 2007).

There is much evidence that correction of iodine deficiency has been followed by a “coming to life” of a community suffering from the effects on the brain of hypothyroidism due to iodine deficiency. Such an increase in vitality is responsible for improved learning by schoolchildren, improved work performance of adults, and a better quality of life. The economic significance of the prevention of iodine deficiency disorders needs to be clearly understood. Education about these basic facts has to be repeated, with the inevitable changes over time in Ministries of Health and the public heath community and salt producers. Otherwise, a successful programme will lapse, as has occurred in a number of countries.

2.11.5 Iodine supplementation

In some countries and areas with insufficient access to iodized salt for vulnerable groups of the population, additional temporary strategies need to be considered to ensure optimal iodine nutrition for these groups while strengthening the salt iodization programmes to reach universal coverage (WHO,2007).

In particular, each country should assess the current situation of its salt iodization programme to identify national or sub national problems and to update its strategies and action plans. The most vulnerable groups, pregnant and lactating women, should be considered for supplementation with iodine until the salt iodization programme is scaled up. For children seven to 24 months of age, either supplementation or use of iodine-fortified complementary foods may be a possible temporary public health measure.

Table 4: Recommended dosages of daily and annual iodine supplementation

population groups	**Daily dose of iodine supplement (µg/d)**	**Single annual dose of iodized oil supplement (mg/y)**
Pregnant women	250	400
Lactating women	250	400
Women of reproductive age (15–49 y)	150	400
Children < 2 y a,b	90	200

a For children 0–6 months of age, iodine supplementation should be given through breast milk. This implies that the child is exclusively breastfed and that the lactating mother received iodine supplementation as indicated above.
b These figures for iodine supplements are given in situations where complementary food fortified with iodine is not available, in which case iodine supplementation is required for children of 7–24 months of age.

2.11.6 Sustainability:

The progress made with IDD programs in the past decade reflects program maturation, and raises the question of how well these programs will be sustained into the future. IDD cannot be eradicated in one great global effort like smallpox and, hopefully, poliomyelitis, since these are infectious diseases with only one host: man. Once eliminated, they cannot come back. By contrast, IDD is a nutritional deficiency that is primarily the result of deficiency of iodine in soil and water. IDD can therefore return at any time after their elimination if program success is not sustained.

Indeed, there is evidence that iodine deficiency is returning to some countries where it had been eliminated in the past (WHO, 2007).

Ideally, salt iodization programs ensure that there is adequate iodine intake for the entire population, and the cost of iodization is included as part of the cost of doing business within the salt industry. The IDD program in this case simply needs to monitor the situation.

In reality, even with mature salt iodization programs with high coverage, programs remain vulnerable to changes in the salt industry, changes in political will, and changes in awareness or consumer acceptance. Thus, it is important to monitor the overall programmatic indicators as well as measures of salt iodization and impact to ensure that achievements are sustained.(WHO, 2007)

2.11.7 Monitoring achievement

Sustainable programmes must have a monitoring system that provides basic information about salt iodization, and about population iodine status. This includes monitoring the proportion of households using iodized salt adequate to meeting iodine intake needs, and assessing iodine status through population-based median urinary iodine levels. Monitoring needs to provide information on where problems may arise at different levels in the salt iodization production and distribution system that might contribute to less-than-optimal iodine status. This includes measures of quality assurance at production facilities, or measures of compliance with government requirements for imported salt.

When the monitoring system is robust, corrective measures are taken to ensure that iodized salt use provides adequate intake, and this is confirmed by periodic population assessment, including understanding the status of pregnant and lactating women. .(WHO, 2007)

Monitoring political support and program strength Programmatic indicators have been used in the past to assess program strength and political commitment. These indicators have been revised. The indicators included reflect the degree to which political commitment is present and likely to continue, and different program elements critical to sustainability. .(WHO, 2007)

Sustainable programs should have mechanisms for oversight such as a multisectoral coalition. They should have political commitment reflected in budget allocation for program activities, and should have established the legislative and regulatory environment for salt iodization. There should be mechanisms for ongoing public education, and inclusion of information on IDD in education curricula. There should be strong partnership with the salt industry, with evidence of their participation reflected in sound quality assurance measures and absorption of the cost of potassium iodate into the cost of doing business. And there should be, as noted above, mechanisms for adequate monitoring of salt and iodine status, periodic reporting, and establishment of an ongoing national database to track sustained progress. With these elements in place, and with achievement of high iodized salt use, programs have reduced vulnerability, and are likely to be sustained.(WHO, 2007)

2.12 National Iodine Deficiency Disorders Control Programme (NIDDCP)

2.12.1 Introduction

Iodine is one of the essential micronutrient for normal human growth. Our daily minimum requirement of iodine is 150 microgram per day. The main source of Iodine is from soil and water. The requirement is met from food (cereals and grains) grown in soil rich in iodine, but food grown in iodine deficient soil result in less iodine in food. Deficiency of iodine in diet may result in development of Goitre and other Iodine Deficiency Disorders (IDD).(NIDDCP, 2009).

2.12.2 Action Plan:

2.12.2.1 Monitoring quality of Iodized Salt:

(A) Monitoring through Food Inspectors

In Haryana there is a complete ban on sale on non-Iodized salt for human consumption, & food Inspectors of State Govt. are responsible for monitoring the quality of food items including iodized salt, and to insure that specifications stated under PFA Act are adhered to. Each food Inspector has been allotted a target to collect two sample of salt per month per district and send it to notified food laboratory. Through this system only limited numbers of salt samples collected from traders/retailers is analyzed. (NIDDCP, 2009).

(B) Monitoring through Health Workers

The Spot Testing Kits method is used for monitoring trends in consumption of iodised salt at household level. For this multi purpose Health Workers(MPHW) has been supplied with STK to test at least five samples of salt per month at consumption level with the following objectives:

(i) To ensure availability of iodized salt and advise local shop keepers to stock only iodized salt as sale of non-iodized salt is banned under PFA Act.

(ii) To identify specific area where population is not purchasing/consuming iodised salt and advise them to consume only iodised salt and create awareness on beneficial effect of iodine in preventing iodine deficiency disorders. The reports are to be discussed in monthly meetings at CHC level and to ensure that Health Workers advise retailers/Consumers of villages where salt samples with nil or less than 15 ppm are reported. These reports should be sent to District Health Officer & compile reports from districts should reach State IDD cell. (NIDDCP, 2009).

Some of the district has informed that STK are exausted and supplies from UNICEF are not coming, so they are requested to sent 10-15 salt sample per month (20-25 gms in small polythene pouches) to State IDD. Laboratory established at State Public Health Laboratory Karnal to check the quality of Iodized salt. (NIDDCP, 2009).

2.12.2.2 Monitoring through School Health Programme:

Members of school heatlh team during their visit to schools will look for IDD's including Goitre in Children and ask students to bring salt samples from their homes for testing with STK (They may collect STK from DHO) & inform the children consuming salt with nil or less than 15 ppm of iodine to discontinue the use of this salt. DSMO will ensure distribution of IEC material on IDD and educate the children to make them aware of iodine deficiency disorders. (NIDDCP, 2009).

2.12.2.3 ***District Nodal Officer (IDD) will get prepared the IEC material*** **and get** distributed through health workers. The budget will be provided to the Civil Surgeons. The IEC material received from Government of India and printed at the State head quarter will be sent to them regularly.

2.12.2.4 Laboratory for testing of salt samples for iodine content (Non PFA)

Collected by MPHW and urine samples for urinary iodine excretion has been set up at state bacteriologist laboratory, Karnal. It has been decided to start testing urinary Iodine Excretion of Pregnant women at district level hospitals on antenatal day to access bioavailability of Iodine in them, to prevent Iodine deficiency in fetus/new born child. (NIDDCP, 2009).

2.12.2.5) Base line survey to assess the status of IDD:

Goitre will be conducted by Central survey team/ MPHWs under supervision of MO I/C of CHCs in the state.

2.12.2.6) An effective IEC strategy is essential to promote universal consumption of Iodised salt. Community awareness on IDD be increased by involving multi-sectoral groups such as Anganwari workers, Panchayati Raj institutions and local bodies in addition to NGOs and other Government departments like food and supplies, ICDS, Education etc. at Civil Surgeon level. (NIDDCP, 2009).

2.13 Strategy for effective salt iodization:

2.13.1 Keys to successful IDD elimination program:

There are many important factors which influence the success and in particular the sustainability of an effective IDD elimination program. The Islamic Republic of Iran (I.R. Iran), a developing country on nutrition transition has been successful in conducting a sustainable program for the last 19 years. (Azizi, 2008).

In the following; this publication will refer to some of the actions in this model of an IDD elimination program:

2.13.2 Political commitment:

Several health and nutrition programs compete for priority action by policy makers. Raising the level of awareness about the problem and the effectiveness of its control within a short period through salt iodization has been an important factor in generating the political will to support serious control and monitoring efforts. Awareness was created in Iran by assessing and making available epidemiological information on IDD prevalence between 1982–1989 and the meaning of the data to high-level politicians and bureaucrats. To obtain the best results, this event was initiated by both scientists and health managers in a collaborative effort.(Azizi, 2009).

2.13.3 Multiple sectors involvement in the planning and administration:

Although the responsibility for initiating, coordinating and monitoring an IDD elimination program rests primarily with the health sector, its planning and implementation requires active involvement of other sectors. The National Committee for Control of IDD (NCCIDD) in Iran includes high officials in industry, trade, planning and transport with active participation of legislators, communicators and educators in order to implement and integrate iodization into salt production and distribution system. (Azizi, 2009).

2.13.4 Advocacy with the salt manufacturing and trading community:

Since the salt sector is the key player in the project, its motivation and involvement is an essential prerequisite. The governmental sector and the salt industry should work closely, understand and recognize each other's points of views, concerns and interests. The manager of the program in Iran fully supported communication and orientation, and provided technical, as well as marketing and financial support to the salt industry.

The commitment of salt producers to produce iodized salt led to effective iodization of salt in the region. (Azizi, 2009).

2.13.5 Information, education and communication (IEC) campaigns incorporating a social marketing approach:

Public awareness and publicity is also necessary so that there is a demand for iodized salt. In the case of a dual market, (both iodized and non-iodized salts available) it is necessary to make the public aware and raise such a demand; once the iodization of salt for human use becomes mandatory, periodic public education for proper storage and usage of iodized salt should continue. Consumers have to be convinced of the importance of iodine to their health. Therefore, people's knowledge about goiter and other less obvious manifestations of IDD were addressed in educational strategies. A social marketing approach enhances the IEC component, by focusing messages on the perceptions and attitudes of consumers. In Iran, the actual communication of these messages was achieved in a variety of ways, including print media, radio, television, traditional theatres and face-to-face counseling. (Azizi, 2009).

2.13.6 Economic and marketing incentives:

In Iran, potassium iodate was provided free of cost to producers for the first 5 years of the program. The salt factories were assisted in the procurement of iodization equipment and by the provision of technical assistance in production and quality control.

2.13.7 Monitoring of iodine levels in salt:

The preparation of iodized salt is only the first stage of the process by which it eventually reaches the consumer. The likelihood of an effective salt iodization program depends on the salt production and distribution process. This needs to be analyzed carefully prior to the initiation of a program. It will enable the incorporation of the iodization process with minimum disruption of the existing system of salt production and distribution. Every successful iodization program depends on a number of support measures to enhance its effectiveness.

To enable a successful salt iodization program in Iran, frequent testing of iodine levels at iodization plants was undertaken as well as periodic controlling at intermediate points in the distribution network, retail outlets and household levels. (Azizi, 2009).

2.13.8 Legislation and enforcement:

Legislation is an important factor in the success of IDD elimination programs. Surveys made four years after the initiation in 1994 of salt iodization in Iran showed that only 50–70 % of the rural and urban population had used iodized salt. Therefore, legislation was passed to ensure that all salt for household consumption was iodized and produced in bags of 700–1000 grams convenient for domestic use. Subsequently the percentage of household consumption of iodized salt increased to > 90 %.(Azizi, 2009).

2.13.9 Contributions of external donors:

This has been critical to the success of initial and often ongoing efforts for salt iodization in many countries. In almost all developing countries, international financing has been responsible for the establishment of IDD elimination programs under which salt iodization is implemented. External technical consultation and international training of national technical staff involved in different parts of the program in Iran was sponsored by appropriate offices of WHO and UNICEF and contributed to the development of iodization activities. (Azizi, 2009).

2.13.10 Program monitoring:

National monitoring programs should include the following activities: periodically monitoring of salt iodine levels in retail shops and households using reliable test kits, and regularly measuring urinary iodine content. In order to determine the proportion of households using adequately iodized salt in a large geographic area, it is recommended that cluster surveys be employed at provincial or national levels. It is also important to identify high-risk communities, or “hot spots" where there is an inadequate proportion of households using adequately iodized salt. (Azizi, 2009).

2.13.11 Leadership:

The leadership for implementation of the program should reside in the ministry of health, with a manager selected from the department dealing mostly with community nutrition. Coordination between different sectors, whether governmental or private, and supervision on the entire program during and after implementation are the responsibilities of the manager of the program. The scientific leadership should be offered to an institute or research center to provide scientific consultancy and to conduct periodic research and ministration.

In the I. R. Iran, the Endocrine Research Center of Shaheed Beheshti University of Medical Sciences in cooperation with the Institute of Nutrition conducted the scientific leadership of the IDD program in Iran. They worked closely with the manager for designing, planning, and interpretation of surveys, monitoring and supervision from the outset of the program. (Azizi, 2009).

2.13.12 National ownership for a sustainable program:

An effective, functional national body for control of IDD should be responsible to the government for elimination program of IDD. This council was formed by the Minister of Health and should be multidisciplinary involving the relevant sectors for nutrition, medicine, salt industry, education and the media, with a chairman appointed by the Minister of Health. (Azizi, 2009).

2.14 Iodine supplementation:

Iodized oil, potassium iodide and Lugol's iodine solution have been considered for iodine supplementation in regions where salt iodization program has failed, or when iodized salt in not widely available.10 During pregnancy and lactation, iodine requirements increase and recommended dietary intake is set at 250 μg iodine per day. In regions where ≥ 90 % of households consume iodized salt for at least 2 years, and the median urinary iodine shows iodine sufficiency, there is no need for iodine supplementation in pregnant and lactating mothers. In regions without USI or with inadequate iodine supplementation, supplements in the form of daily oral potassium iodide to meet requirement of 250 μg iodine per day or an oral dose of 400 mg of iodized oil should be given.(WHO, 2007)

2. 15 Technical Specifications for iodized salt:

2. 15.1 Scope

This specification applies to **Iodized Salt** distributed by WFP.

2.15.2. Raw materials

2.15.2.1 Salt

Salt used for Iodized Salt conforms to Codex Standard for Salt (CODEX STAN 150-1985, Rev. 1-1997).

2.15.2.2 Iodine Source

Potassium iodate ($KIO3$) added in salt shall be of food grade quality and conform to all applicable Codex standards.

Iodized Salt producers should purchase potassium iodate from WFP approved premixes suppliers: BASF (Stern Vitamin), Fortitech, Nicholas Piramal, Hexagon Nutrition or their authorized dealers and gain premix facility.

2.15.3 Processing:

The production of salt shall only be performed by reliable manufacturers having the knowledge and the equipment requisite for the adequate production of food grade salt.

For compliance with Codex standards the manufacturers must be able to demonstrate by principle and practice the adoption, implementation and recording of:

- Good Manufacturing Practice
- Hazard Analysis Critical Control Point program

The manufacturer must be registered under national food law as a manufacturer of foods for human consumption.

2.15.4 Product specification:

2.15.4.1. General requirements:

Iodized Salt is dried, sieved, edible and iodized for human consumption.

- Sodium chloride as NaCl: min 97.0 % (on dry matter)
- Moisture content: max 3.0% (m/m)
- Water insoluble matter: max 0.2 % (m/m)
- Iodine: 30.0 – 50.0 mg/kg (means 50 – 84mg of potassium iodate per kg of salt)
- Colour: shall be white and 10 g of salt in 100 ml water shall give a colourless solution having a neutral reaction.

2.15.4.2 Particle size distribution

Regular salt

- min 85 % pass through 1.00 mm sieve
- max 20 % pass through 0.212 mm sieve

***Otherwise**:* particle size will be specified in the purchase contract.

2.15.4.3 Food additives

Food additives listed in Tables 1 and 2 of the Codex General Standard for Food Additives (CODEX STAN 192-1995) in Food Category 12.1.1

(Salt) may be used in foods subject to this standard. All additives used shall be of food grade quality. (FAO, 2013).

2.15.4.4 Chemical contaminants

Contaminants in the **Iodized Salt** shall not exceed the following levels:

Table 5: Limit of chemical contamination in Iodized Salt:

Item	Maximum
Alkalinity (as Na2CO3)	0.1 % (m/ m)
Acid insoluble matter	0.15 %(m/m)
Sulphate (SO4)	0.5 % (m/m)
Arsenic	0.5 mg/ Kg
Copper	2.0 mg/ Kg
Lead	2.0 mg/ Kg
Cadmium	0.5mg/Kg
Mercury	0.1mg/Kg
Calcium	o.5%(m/m)
Tin (as Sn)	100.0 mg/Kg

Iodized Salt shall not contain other contaminants and toxins in amounts which may represent a hazard to health.

2.15.5. Packaging

Iodized salt shall be packed in air tight bags of either high density polyethylene (HDPE) or polypropylene (PP) (laminated or non-laminated) or LDPE-lined jute bags (Grade 1803 DW jute bags lined with 150 gauge polyethylene sheet).

2.15.6. Storing:

Iodized Salt must be stored under dry, ventilated and hygienic conditions.(FAO, 2013).

Chapter three

Methods

3.1 Study design:

It is a community based descriptive Cross – sectional study, it was carried out to study prevalence of goitre among population in Shendi locality-River Nile State

3.2 Study area:

Shendi locality is one of the localities of River Nile State. It is bounded by Khartoum state in the south, Elddamer locality to the north, River Nile to the west and Gadarif state to the east. The locality area is about 14596 Km2, The rural areas of the Shendi locality are composed of about 96 villages, 63 of them are at southern side of the locality. Topographically the Locality lies on a' flat mud-sandy area adjacent to the River Nile with a few scattered mountains in the eastern part and is accessible all the year. Geographically it lies between line 36 east to 31 west longitudinal and line 19 north to line 15 south latitudinal in the arid zone of Sudan with an annual rainfall ranging' between 0 and 119/ml per year. It is situated on the main River Nile, which is the source of water for the agriculture. The main cash crops are white beans, onions, wheat and sorghum. Goats and camels are both by the few nomadic 'Rashaida' and the settled farmers,

Culturally the population of Shendi is a mixture of the various cultures that occur in Sudan though the Northern tribes, particularly ElGaalien, are predominant. The population of Shendi locality is estimated to be about 269446. About 60 % of the population is rated as poor. Growth Rate: 2.3%, Male 48.7%, Female % 51.3%. In addition, the average of family size is 6 members. 78% of the population depends upon the agriculture while the rest are traders, teachers and handcraft workers, including spinners, weavers and other artisans.

The literacy rate is high in the towns and villages in the locality. Basic Education consists of (112) primary schools. Secondary Education consist of (17) secondary schools. Shendi University was established in the early 1990s and includes (11) faculties, eight in Shendi locality, and three in Al-matama locality.

Shendi locality is one of the six localities of River Nile State. It has full authority over all administrative affairs in its own area, Shendi locality administratively is divided into four units, Shendi town, Shendi rural, (South rural, North rural), Hagar Al-Asal and Kaposhia.

Many public and private health services were established, to provide health care to the community as listed below:

Health services establishment in Shendi locality :

Administration	***Health services establishment***		
	Hospitals	***Health center***	***Health units***
Shendi town	3	12	1
North rural	2	6	2
South rural	2	21	7
Hajar Elaasal	2	13	1
Kabpshia	1	10	6
Total	10	62	17

(Records, shendi locality, general administration of health and population 2013)

There are many health programs in the locality, (MCH and expanded program of immunization (EPI)).Moreover, environmental Health and Sanitary activities are carried out by the Environmental Health staff.(Records, shendi locality, general administration of health and population 2013)

Number of health staff in the health services in Shendi locality

Administration	***Health staff in the health services(graduates)***					
	Specialist	***Registrar***	***General doctor***	***Nurses***	***Lab Technician***	***Radiology techniques***
Shendi town	42	13	73	140	40	10
North rural	1	-	3	1	2	1
South rural	-	-	2	1	2	-
Hajar Elaasal	-	-	1	1	-	-
Kaboshia	-	-	1	-	-	-
Total	43	13	80	143	44	11

(Records, shendi locality, shendi teaching hospital general administration of health and population 2013)

Technical. assistant staff in the health services in Shendi locality

Administrations	**Number of Technical assistant staff**					
	Medical Assistant	***Public health officer***	***Nurses***	***Health visitors***	***Health visitors assistant***	***Public health overseer***
Shendi town	4	3	2	1	3	2
North rural	1	2	8	-	4	1
South rural	12	1	5	1	6	1
Hajar Elaasal	7	-	3	-	3	-
Kaboshia	3	1	4	-	4	1
Total	27	7	22	2	20	5

(Records, shendi locality, general administration of health and population 2013)

3.3 Study population:

The study population were households residents in Shendi locality. The total number of households in Shendi locality was 53889 households (Sudan central bureau of statistics. 2008).

- **Inclusion criteria:**

The inclusion criterioa was all ages of population in study area.

3.4 Sample size:

The sample size was determined for study area using the formula for cluster surveys. It was calculated on the basis of prevalence of 50% and design effect of 1.5. using the following formula

$$n = \frac{z^2 * p * q}{d^2} * \text{Deff}$$

Where:

Z is the value of the standard normal variable corresponding to 95% level of significance (z =1.96)

P= 0.5 since there is no prior information.

q= 1-p = 0,5

D= is a margin of error d = 0.0476

Deff = 1.5

Accordingly after substitution we found a sample size of 636 households was considered.

The sample size of households surveyed was based on the assumed goiter prevalence rate of 50% (as there was no available information on likely prevalence in the study district), confidence interval (CI) of 95%, a design effect of 1,5 and a relative precision of 10%. A sample size of 636 household was considered sufficient to establish whether goiter was present.

The sample size was distributed for each administrative unit using the following formula:

$$Ns = \frac{n * ws}{N}$$

Where:

Ns = sample size in each administration.

n= total sample size.

ws= number of population in each administration.

N =number of total population.

The distribution of sample size by administrations:-

administrative units	Number of households	Sample size
Shendi town	13053	154
Kabosheia	9926	117
Rural (north & south)	20046	237
Hagar Alasal	10864	128
Total	53889	636

3.5 Sampling techniques:

The multistage cluster-sampling technique was followed for selecting the study population in three stages .

First stage:

The locality was divided into four administrative units, the three clusters were selected using the 'probability proportional to size' (PPS) sampling method.

Second stage:

All administrative units were divided into cluster villages or block (cluster sampling technique). A random sampling technique is then used on any relevant clusters to choose which villages or block to include in the study in each identified cluster.

Third stage:

All households of the selected cluster enlisted. An attempt was made to select an equal number of household in the unit as far as possible. The required number of households in each village and block was selected by following the systemic random sampling technique .The sample size was distributed for each village using the following formula:

K= N/n

Where:

K= interval.

N= population.

n= sample.

3.6 Data collection:

Method **used** for collecting data to satisfy the objective of the study is:

1. Questionnaire is one of the tools used for survey in collecting data. Public health officers and students were trained on questionnaire to participate in survey. Questionnaire included different types of questions such as:

a. Open ended questions.

b. Closed ended questions.

- Closed ended questions with unordered responses.
- partially Closed ended questions.

c. Dichotomous questions and.

d. Contingency questions.

They are all about Knowledge of goiter, iodine and its sources, environmental factor such as sources of drinking water, Knowledge of iodized salt and food consumption…..etc. the questionnaire was annexed as annex No 1.

2. Observation was used for detection the level or grade of goiter among goiterous peoples. Researcher used some questions included in the questionnaire as check lest to confirm it.

3.7 **Validity of the Questionnaire:**

To verify the validity of the study, the researcher after that presented the questionnaire to a committee of five experts medical and public health staff at the University of Shendi, faculty of medicine and faculty of public health , to approve and reassure the validity and to what extents the questionnaire statements and phrases were clear and appropriate to the study. all of them gave their valuable contribution by adding, excluding or amending some of the statements of the questionnaire. So the questionnaire validity was of a high stability and an internal consistency.

3.8 Data Analysis s:-

After the data was collected, they are coded and transferred into a specially designed formats so as to be suitable for computer feeding by using the following computer programmers:

- Statistical Package for Social Sciences (SPSS version 11.5): was used for analysis and to perform Pearson Chi square test for statistical significance (P value).and correlation test.

Following data entry, checking and verification process were carried out to avoid any errors during data entry. Frequency analysis, cross tabulation, and manual revision were all used to detect any errors. The following statistical measures are used:

1. Descriptive measures include frequencies, percentage, standard deviation, minimum and maximum.
2. statistical test include : Chi square test , T test was used for quantitative variables
3. Graphical presentation includes Bar graph, Pie graph.
4. The level of significance selected for this study was P value equal to or less than 0.05.

- ***Ward program:*** used for export the tables contain frequency, percentage, and figures of variables.
- ***Excel program:*** used for made graphical presentation include Bar graph and Pi chart.

3.9 Limitations of the study:

The researchers were faced with many logistic problems and spent much effort to perform and implement this study. They were faced with delayed funds, transportation and refusals of some person due to culturally related fears, and believe that they are not targeted .

3.10 Ethical considerations:

The proposal was approved by faculty of public health board then submitted to the post graduate board and approved too. The consent letter was obtained from health authority (head quarter of general administration for health and population).

At the initial interview of each potential subject was informed about the nature, purpose and benefits of the study, and informed that his participation is voluntary.

The researcher assured that the collected data and information will be confidential and would be used only to improve their health and for the purpose of the study.

It was understood that most interviewees in will find the discussion interesting and thought-provoking. If, however, they feel uncomfortable in any way during the interview session, they have the right to decline to answer any question or to end the interview.

Participants understood that the researcher will not mention their name in any reports using information obtained from the interview, and that their confidentiality as a participant in this study will remain secure. Subsequent uses of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions.

Chapter four
Results

Table 1: fathers occupation of the household in Shendi locality River Nile State.

Occupation of father	Frequency	Percent
Farmer	**188**	**29,6**
Laborer	**258**	**40,6**
Employee	**127**	**20,0**
No Laborer	**63**	**9,9**
Total	**636**	**100**

Table 1. describes occupation of father, the data reveals that (40.6%) of population were laborer and (9.9%) have not specific occupation.

Table 2: Shows mothers occupation in Shendi locality River Nile State.

occupation of mother	Frequency	Percent
Farmer	23	3.6
Laborer	62	9.7
Employee	78	12.3
Housewife	473	74.4
Total	636	100

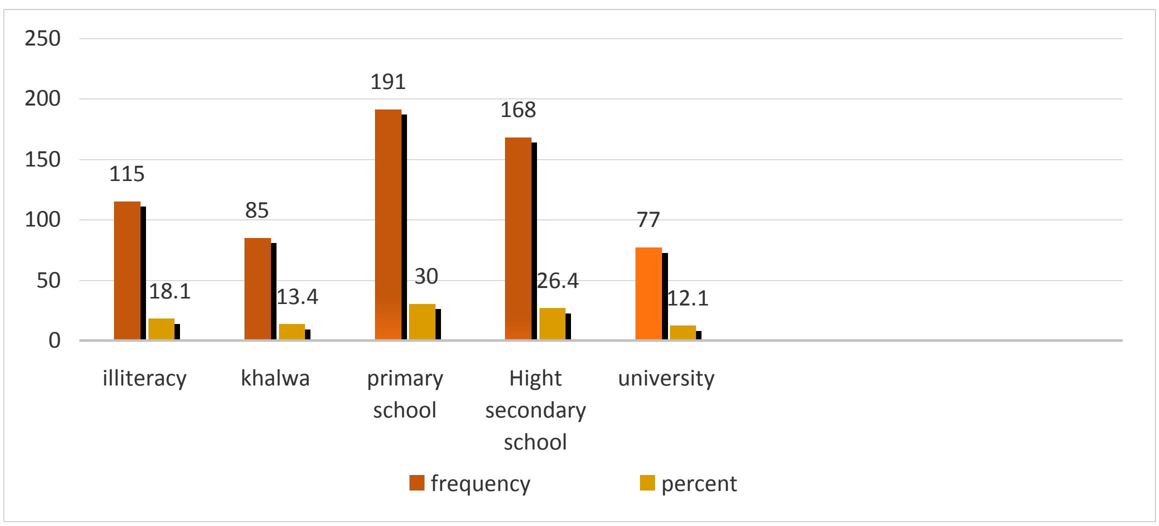
Table 2. describes Mothers occupation, the data Showes that three quarter of population were house-wives (74.4%) and (3.6%) of them work in farms.

Table 3: Family income per month in Shendi locality River Nile state.

Family income per month	Frequency	Percent
Less than 500 pound	261	41.0
500 - 1000 pound	305	48.0
Above 1000 pound	70	11.0
Total	636	100

Table 3. Shows the monthly income of families which is varied, the category (500-1000 pound) represent the highest frequency among population, while the category above 1000 has the lowest frequency. This means that the community of Shendi locality is poor.

Figure 1 : Father educational level in Shendi locality River Nile state.



N =636)

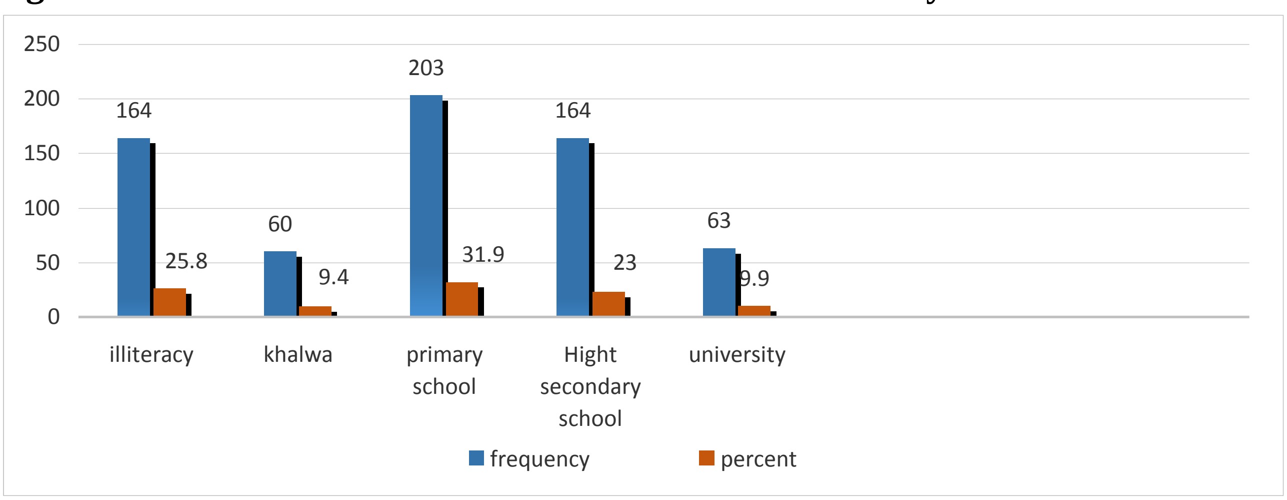
Fig. (2) indicates that the educational level of father is higher in the primary school level (30%) while the university level has a very low one (12.1%) and 18% were illiterate.

Table 4: distribution of father educational level in the administrative units in Shendi locality river Nile state.

Educational levels	Distribution in administrative units									
	Shendi town		Rural		H.Elasal		Kaboshia		**Total**	
	N	%	N	%	N	%	N	%	**N**	**%**
Illiteracy	24	3.8	32	5	32	5	26	4.1	**114**	**17.9**
Khalwa	17	2.7	36	5.7	17	2.7	15	2.4	**85**	**13.5**
Primary School	39	6.1	59	9.3	42	6.6	52	8.2	**192**	**30.2**
High secondary School	48	7.5	82	12.9	21	3.3	17	2.7	**168**	**26.4**
University	26	4.1	28	4.4	16	2.5	7	1	**77**	**12**
Total	**154**	**24.2**	**237**	**37.3**	**128**	**20.1**	**117**	**18.4**	**636**	**100**

Table 4. shows that the primary School level represents a high percent (30.2%). (9.3%) of them in rural area (North and South), while the universal level represents the lowest one (12%) that means the educational level is poor in population.

Figure 2: The educational level of Mother in Shendi locality River Nile state.



(N =636).

Fig. (2) indicates that the educational level of mother is high in the primary school level (31.9%) while the university level is very low (9.9%) .

Table 5: distribution of Mother educational level in administrative unites in Shendi locality river Nile state.

Educational levels	Distribution in administrative units									
	Shendi town		Rural		H.Elasal		Kaboshia		Total	
	N	%	N	%	N	%	N	%	N	%
Illiteracy	**37**	**5.8**	**54**	**8.5**	**48**	**7.5**	**25**	**3.9**	**164**	**25.7**
Khalwa	**8**	**1.3**	**20**	**3.1**	**13**	**2**	**19**	**3**	**60**	**9.4**
Primary School	**45**	**7.1**	**75**	**11.8**	**35**	**5.5**	**48**	**7.5**	**203**	**31.9**
High secondary School	**51**	**8**	**59**	**9.3**	**19**	**3**	**17**	**2.7**	**146**	**23**
University	**13**	**2**	**29**	**4.7**	**13**	**2**	**8**	**1.3**	**63**	**10**
Total	**154**	**24.2**	**237**	**37.4**	**128**	**20**	**117**	**18.4**	**636**	**100**

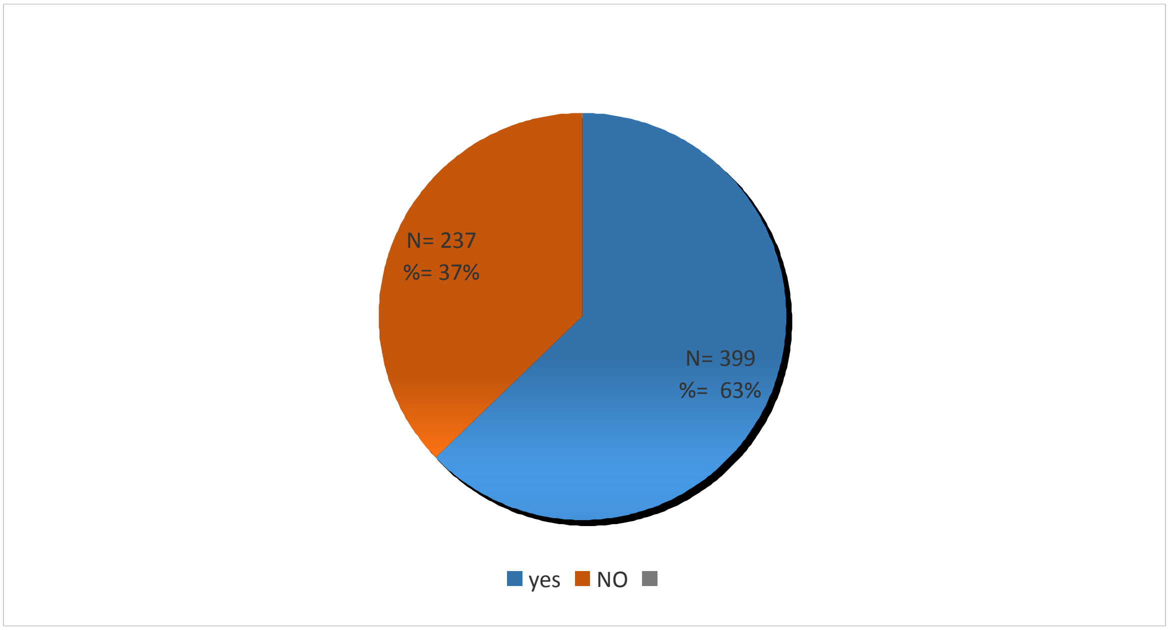
Table 5: shows that the primary School level represents a high percent (31.9%). (11.8%) of them in rural area (North and South), while the universal level represents lowest one (10%) that means the educational level is poor in population.

Table 6: Family size in Shendi locality River Nile state..

Family size	Frequency	Percent
less than 6	364	57.2
6 -9	222	34.9
above 9	50	7.9
Total	636	100

Table 6. Shows the family size which varies, the category (less than six) represents the half of the population (56.2%), while the category (above 9) has the lowest frequency.

Figure (3): Knowledge of population about goiter disease in Shendi locality River Nile state.



(N =636).

Fig: (3) demonstrates knowledge of population about goiter disease, most of population have knowledge (63%).

Table 7: Knowledge of population about definition of goiter disease in Shendi locality River Nile state.

Definition of goiter	Frequency	percent
enlargement of thyroid gland	369	92.5
Don't know	30	7.5
Total	399	100

Table 7. indicats that most of the population think the enlargement of thyroid gland is suitable definition of goiter disease (92.5%).

Table 8: Knowledge of population about causative agent of goiter disease in Shendi locality River Nile state.

causative agent of goiter disease	Frequency	percent
Decrease of iodine in food	350	87.7
Other causes	49	12.3
Total	399	100

Table 8. Shows the decrease of iodine in food represents a high frequency in the study (87.7%), while other (12.3%) suggest that there are other causes like depression.

Table 9: Knowledge of respondents about iodine and its definition in Shendi locality River Nile state.

Definition of iodine	Knowledge of respondents about iodine					
	Yes		No		Total	
	N	%	N	%	N	%
	351	55	285	45	636	100
Chemical element	**274**	**78.1**	-	-	-	-
Chemical compound	**61**	**17.4**	-	-	-	-
Don't now	**16**	**4.5**	-	-	-	-
Total	**351**	**100**	-	-	-	-

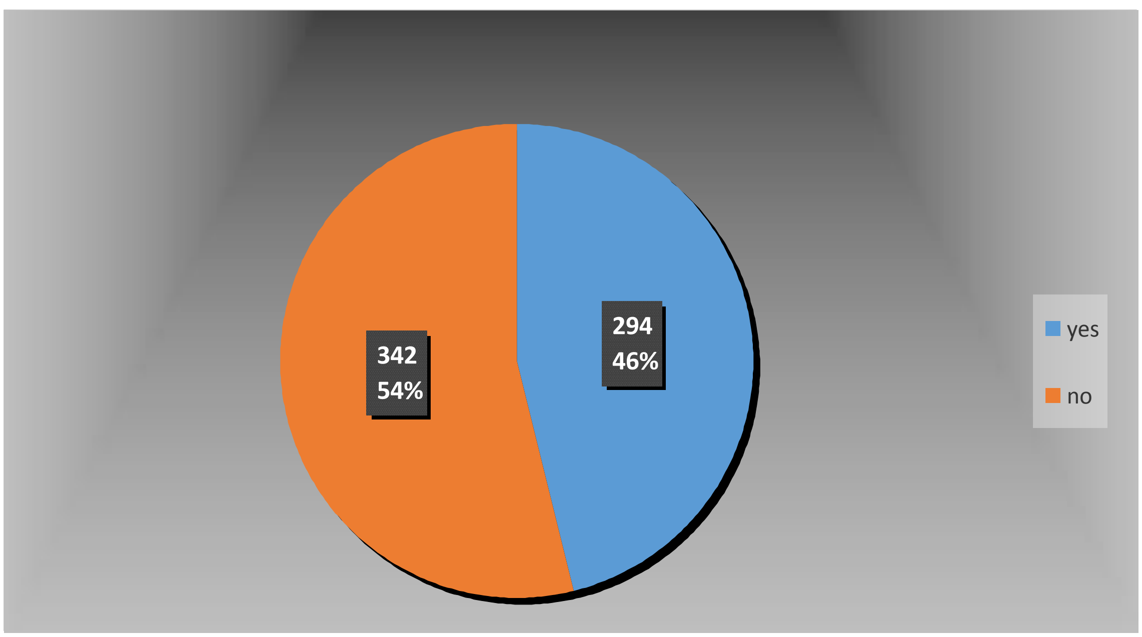
Table 9. demonstrates that more than half respondents have knowledge (55%), (78.1%) of them define the iodine as a chemical element. While (45%) have no knowledge.

Table 10: Knowledge of respondents about sources of iodine in Shendi locality River Nile state.

Sources of iodine	Frequency	percent
Seas water	129	30.6
Soil	124	29.5
Food	159	37.8
Other	9	2.1
Total	421	100

Table 10. Shows that the food is the more common source of iodine (37.8%) than seas water which represents (30.6%) in the study, while the soil represents (29.5%).

Fig 4: Knowledge of respondents about foods contains iodine in Shendi locality River Nile state .



(N =636).

Fig 4. Shows the Knowledge of respondents about food that contain iodine, the data revealed that more than half of population (54%) know, while (46%) don't know.

Table 11: Classification of foods contains iodine in Shendi locality River Nile state.

Classification of foods	Frequency	percent
Fish	206	44.4
Milk	145	31.3
Eggs	98	21.1
Don't know	15	3.2
Total	464	100

(44.4%) of respondents classify fish as the most common food containing a high rate of iodine more than other foods such as milk (31.3%) and eggs (21.1%).

Table 12: Knowledge of respondents about the most iodine deficiency disorder in Shendi locality River Nile state.

Iodine deficiency disorder	Frequency	percent
Goiter	265	75.5
Mental retardation	36	10.3
Abortion	44	12.5
Don't know	6	1.7
Total	351	100

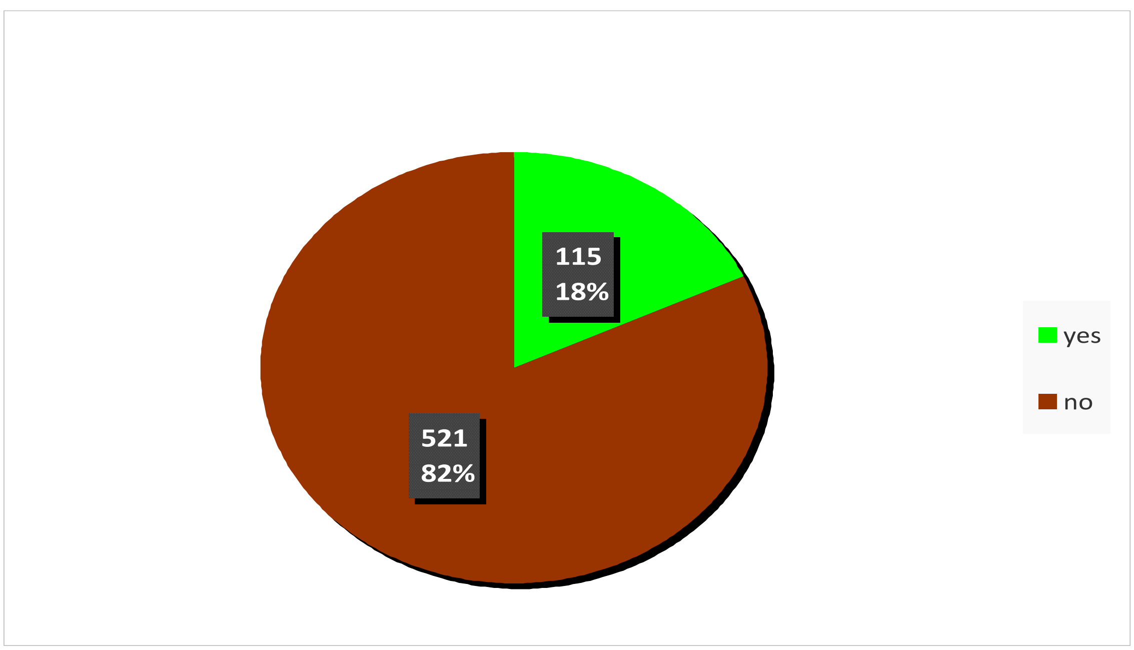
Table 12. demonstrate that respondents consider goiter as one of the most important iodine deficiency disorder caused by iodine deficiency (75.5%).

Table 13: Sources of information about definition, sources, food contains iodine and iodine deficiency disorder in Shendi locality River Nile state.

Sources of information	Frequency	Percent
Television	172	38.9
Radio	117	26.5
Reading	91	20.6
Lecture	42	9.5
Other	20	4.5
Total	442	100

Table : 13. Shows the source of information, the study revealed that television is a good medium of a communication (38.9%) as well as radio (26.5%).

Figure 5: Distribution of goiter disease among households in Shendi locality River Nile State.



(N =636)

The study demonstrate that (18%) of population have goiter disease while (82%) have not.

Table 14: prevalence of goiter disease among population in administrative units / Shendi locality River Nile State.

Prevalence	distribution in administrative unites									
	Shendi town		Rural		H.Elasal		Kaboshia		Total	
	No	%	No	%	No	%	No	%	No	%
Present	23	3.6	27	4.2	34	5.3	31	4.9	**115**	**18**
No present	131	20.6	210	33.1	94	14.8	86	13.5	**521**	**82**
Total	**154**	**24.2**	**237**	**37.3**	**128**	**20.1**	**117**	**18.4**	**636**	**100**

The total goiter prevalence rate was 18% **.** the high rate was showed in Hajer Elasal, (5.3%), Kaboshia, rural (North and South) and urban respectively.

Table 15: Distribution of persons among family member who have goiter in study households/ Shendi locality River Nile State.

persons who have goiter disease	Frequency	percent
Father	24	20.9
Mother	57	49.6
Daughters	34	29.5
Total	115	100

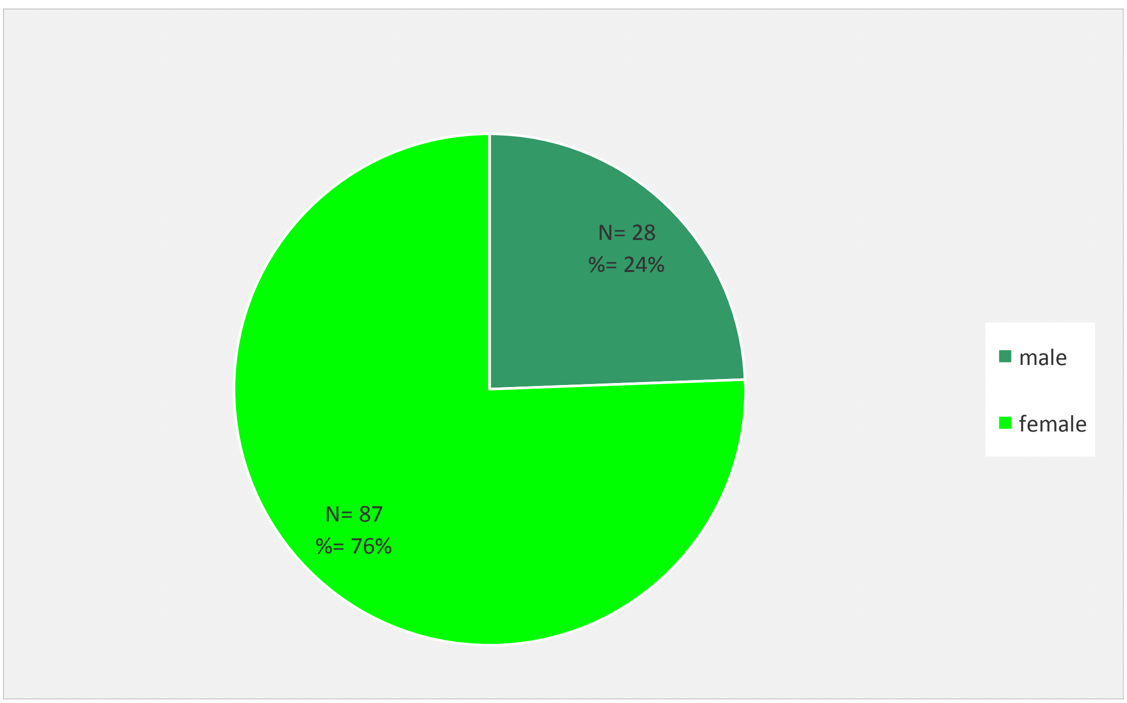
Table: 15. shows the distribution of goiter among family members, it was revealed that mother is highly affected (49.6%) while daughters and father was bellow (29.9%) (20.5%) respectively.

Table 16: Age distribution among patients of goiter disease in population of Shendi locality River Nile State.

Ages of patient affected by goiter disease	Frequency	percent
less than 15 years	2	1.7
16 -30 years	23	20
31 -45 years	50	43.5
Above 45 years	40	34.8
Total	115	100

It can be observed that the age group (31-45 year) represents the common age group of the cases (43.5%), while (less than 15 year) is the least common one.

Figure 6: Distribution of gender among goitrous in population of Shendi locality River Nile State.



(N =115).

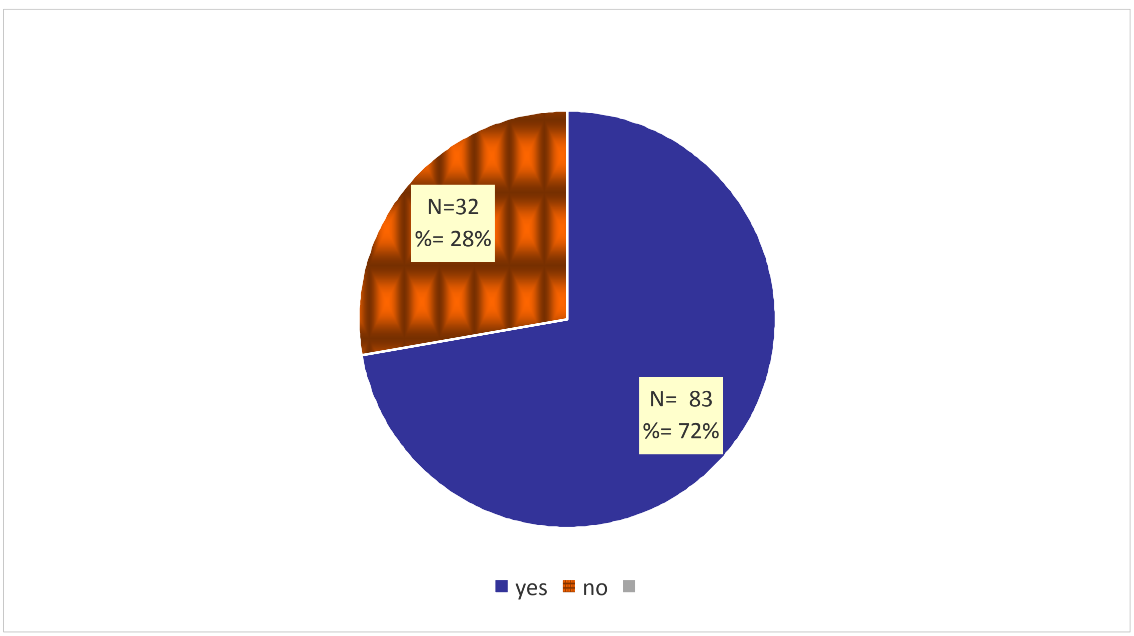
The distribution of goiter disease in population according to gender, revealed that the majority of them were female (76%).

Table 17: levels of goiter disease among affected population in Shendi locality River Nile State.

levels of goiter disease among affected population	Frequency	percent
Not visible	34	29.6
Palpable	31	26.9
Visible	34	29.6
Large	16	13.9
Total	115	100

Table: 17. describe the distribution of a goiter grade among goitrous, it revealed that visible level represents high percent as will as not visible level (29.6%) while large level was lowest (13.9%).

Fig 7: Applying Preventive measurers by affected population in Shendi locality River Nile State.



(N =115)

Fig:7. demonstrates Preventive measurers applied by goitrous. It showed that most of them used it (72%) while others did not use it.

Table 18: Types of preventive measurers applied by affected population in Shendi locality River Nile State.

Types of preventive measurers	Frequency	percent
Oral iodide	32	38.6
Injectable iodide	15	18.1
Iodized salt	20	24.0
Food contain Iodine	16	19.3
Total	83	100

(38.6%) of goitrous applied preventive measurers used oral iodide for eliminating goiter as iodine deficiency disorder.

Table 19: Time detection of goiter disease among affected population in Shendi locality River Nile State.

detection of goiter disease	Frequency	percent
Through this month	8	7
Before 6 month	16	13.9
Before year	33	28.7
More than year	58	50.4
Total	115	100

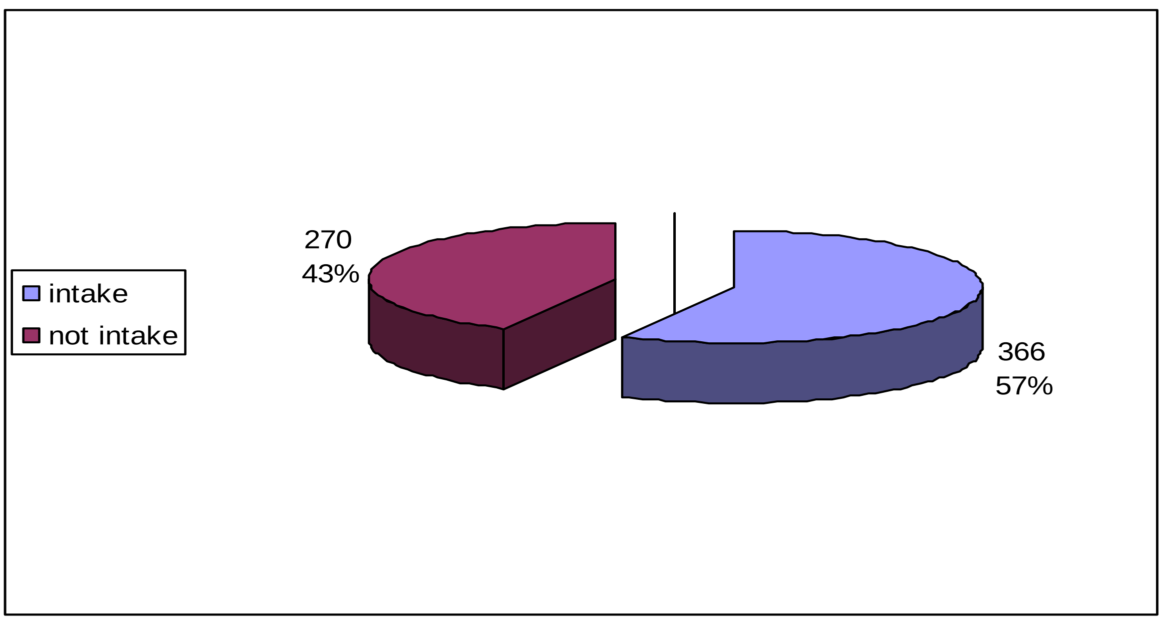
Table 19. Shows the history of goiter among goitrous, it reveals that the detection in more than year represents the half of the population (50.4%) while through month was lower (7%).

Table 20: Sources of drinking water in Shendi locality River Nile State.

Sources of drinking water	Frequency	percent
deep bore wells	456	71.7
Surface wells	61	9.6
Untreated water from River Nile	119	18.7
Total	636	100

It can be observed that the deep bore wells represent the common source of drinking water used (71.7%), while surface wells were the least common one (9.6%).

Figure 8: Fish intake used by residents and its regulation in Shendi locality River Nile State.



(N =636)

Fig 8. illustrates the fish intake used by residents, it was found that (57%) were taking fish while (43%) they do not.

Table 21: Regulatory of fish intake among residents, in Shendi locality River Nile State.

Regulation of fish intake	Frequency	percent
Daily	9	2.5
Weekly	178	48.6
Monthly	179	48.9
Total	366	100

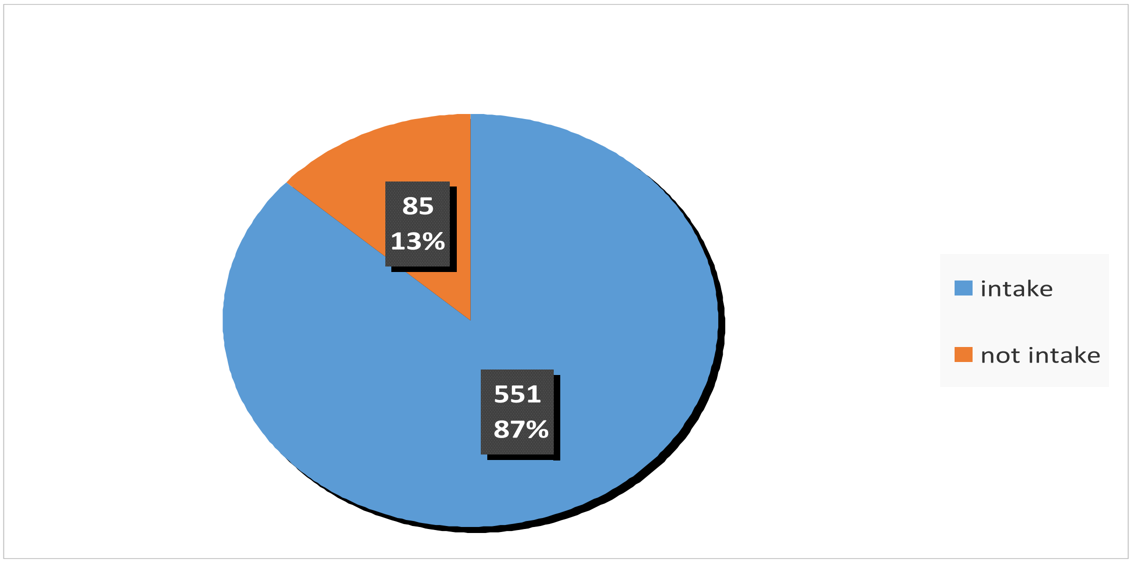
Table 21. describe the regulatory of fish intake among residents, it revealed that monthly intake represents (48.9%) while daily intake represents (2.5%).

Table 22: Reasons behind not taking fish by residents in Shendi locality River Nile State.

Reasons of reject fish	Frequency	percent
Expensive	187	69.3
Not of value	11	4.1
Undesirable	64	23.7
Other	8	2.9
Total	270	100

Reasons of not eating fish were diverse, the high cost of fish represents the main reason for most goitrous family (69.3%), some of them belief that it is not desirable (23.7%).

Figure 9: Eggs intake used by residents in Shendi locality River Nile State.



(N =636)

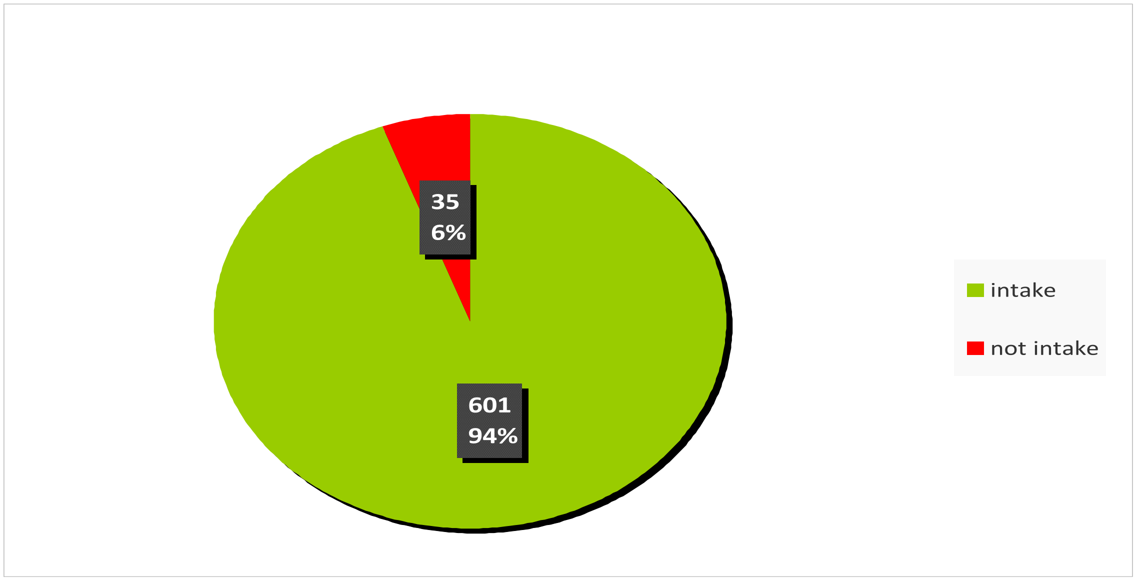
Fig: 9. demonstrates the eggs intake, it was showed that the majority of population were taking eggs (87%), and (13%)was not.

Table 23: Regulatory of eggs intake among consumed population food in Shendi locality River Nile State.

Times of eggs consumption	Frequency	percent
Daily	173	31.4
Weekly	327	59.3
Monthly	51	9.3
Total	551	100

Table 23. Shows the regulatory of eggs intake among goitrous, it showed that weekly intake was most common (59.3%) while monthly intake was least common one (9.3%).

Figure 10: Milk intake by population in Shendi locality River Nile State.



(N =636).

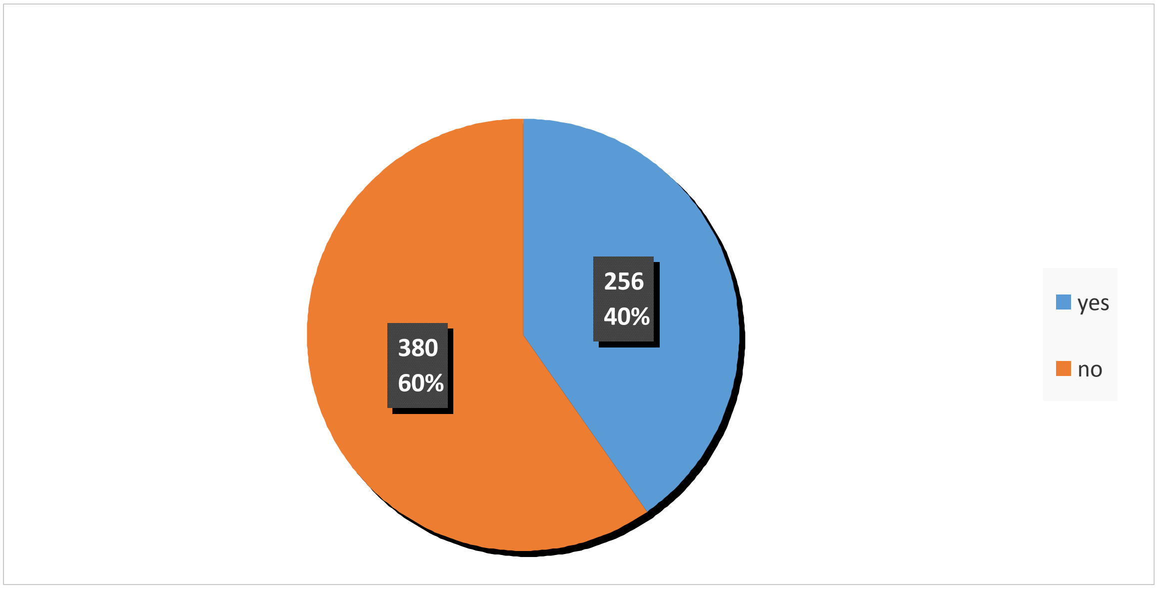
Fig: 10. Shows the milk intake, were the majuraty of the population intake milk (94%).

Table 24: Regulatory of milk intake among consumed population in Shendi locality River Nile State.

Times of Milk consumption	Frequency	percent
Daily	583	97
Weekly	13	2.2
Monthly	5	0.8
Total	601	100

Table 24. demonstrating the regulatory of milk intake, it revealed that daily intake represent highly percent (97%) while weekly and monthly intake represent (2.2%), (0.8) respectively.

Figure 11: Knowledge of population about iodized salt in Shendi locality River Nile state.



(N =636)

Fig: 11. shows that (60%) of resident have no knowledge about iodized salt, while other (40%) have knowledge about it.

Table 34: Knowledge of population about iodized salt in administrative units / Shendi locality River Nile state. (N =636).

Knowledge of population	Percent distribution in administrative units									
	S. town		Rural		H.Elasal		Kaboshia		Total	
	N	%	N	%	N	%	N	%	N	%
Yes	59	9.3	96	15.1	42	6.6	59	9.3	**256**	**40.3**
No	95	14.9	141	22.2	86	13.5	58	9.1	**380**	**59.7**
Total	**154**	24.2	**237**	37.3	**128**	20.1	**117**	18.4	**636**	**100**

People in rural units who have no knowledge about iodized salt represent (22.2%) which is highest compared with other administrative units.

Table 25: Availability of iodized salt in Shendi locality River Nile State.

Availability of iodized salt	Frequency	Percent
Available	134	21.1
Not available	328	51.6
Don’t know	174	27.3
Total	636	100

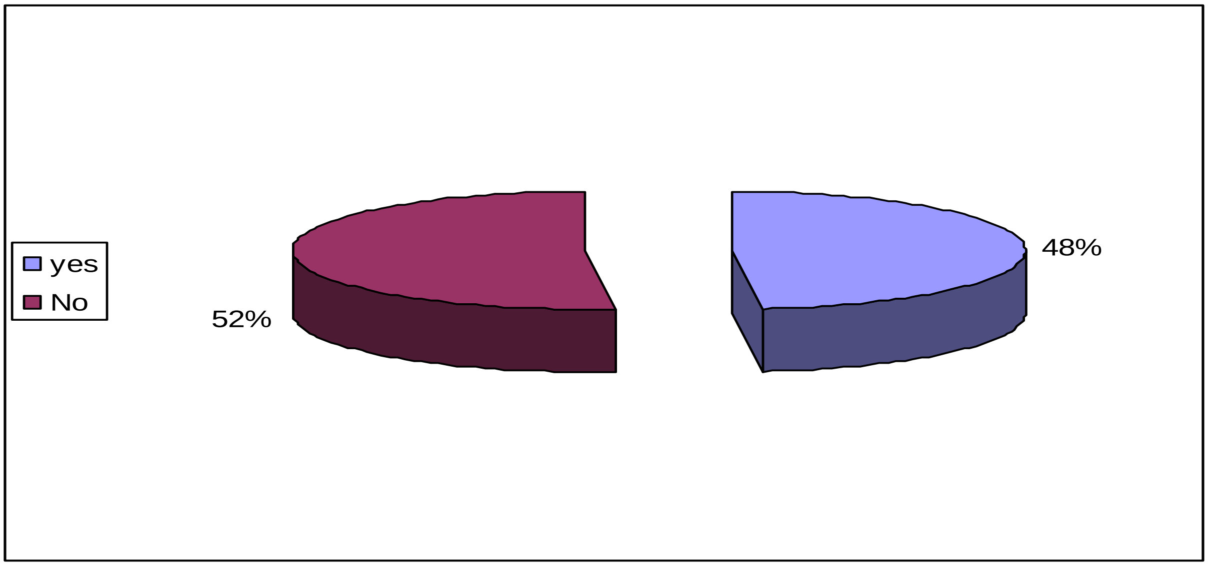
Table 25: described that availability of iodized salt is very low (21.1%). While half of respondents (51.6%) suggested that it’s not available.

Table 26: Consumption of iodized salt in Shendi locality River Nile State.

use of iodized salt	Frequency	Percent
Daily	52	20.3
Weekly	47	18.4
Monthly	157	61.3
Total	256	100

Table 26. Shows the consumption of iodized salt, it revealed that only (20.3%) of community are using iodized salt continuously. while most of them do not use it (61.4%).

Fig: 12.Opinions of population about the necessity of iodized salt in Shendi locality River Nile state.



(N =636)

Fig 12. demonstrates that the half of residents think that the iodized salt was not necessary for intake (52%), while (48%) say that it was necessary.

Table 27: Percent prevalence of goiter and knowledge of respondents about goiter/ Shendi locality. N= (636)

knowledge of goiter	Cases		Total	P. value
	yes	No		
Yes	16.2%	46.5%	62.7%	0.000
No	1.9%	35.4%	37.3%	
Total	18.1%	81.9%	100%	

P<0.05 (chi-square test).

Table 27: demonstrates that residents have no knowledge and nongoitrous represent most of them 81.9% while 18.1% have goiter. And there were statistically high significant .

Table 28: Percent knowledge of goiter and knowledge of iodine in population / Shendi locality. N= (636)

knowledge of goiter	knowledge of iodine		Total	P. value
	yes	No		
Yes	46.5%	16.2%	42.7%	0.000
No	8.6%	28.6%	37.3%	
Total	55.2%	44.8%	100%	

P<0.05 (chi-square test).

Table 28. describes the knowledge of goiter and knowledge of iodine, the data demonstrate that 55.2% of population have knowledge while 44.8% have not and there were statistically high significant.

Table 29: Percent prevalence of goiter and gender in the population in Shendi locality. N= (115)

Levels of goiter disease	Gender		Total	P. value
	Male	Female		
Grate 0	7.8%	21.7%	29.6%	0.000
Grate I	5.2%	21.7%	27%	
Grate II	8.7%	20.9%	29.6%	
Grate III	2.6%	11.3%	13.9%	
Total	24.3%	75.7%	100%	

p>0.05 (chi-square test).

Twenty-four point three percent of male and 75.5% of female have goiter of varying degrees. There were no significant gender differences.

Table 30: correlation between mother educational level and goiter in Shendi locality.

	Mother education (N=636)	Goiter (N=115)
Mother education	1	-,016
Sig. (2-tailed)		.868**
Goiter	-,016	1

** correlation is significant at 0,01 level (2 tailed)

Table 31: correlation between goiter and fish intake in Shendi locality.

	Goitrous (N=636)	Fish intake (N=115)
Goitrous	1	-,076
Sig. (2-tailed)		.056
Fish intake	-,076	1

* correlation is significant at 0,01 level (2 tailed)

Table 32: correlation between goiter and iodinated salt in Shendi locality.

	Goiter (N=636)	iodinated salt intake (N=256)
Goiter	1	-,013
Sig. (2-tailed)		.830**
Iodinated salt intake	-,013	1

** correlation is significant at 0,01 level (2 tailed)

Chapter five

5.2 Discussion

The study was curried out in Shendi locality revealed that (40.6%) of population (fathers) were employee and (9.9%) have no specific occupation. While three quarters of mothers were house-wife (74.4%) and (3.6%) of them work in farms. This lead to classification of most of the population (48%) in middle economic level (500-1000 SP), and that may contribute to lack of iodine intake food and lead to goiter.

Regarding educational levels among population we found that males were more educated than females (12.1%) to (9.9%) for universal level, as well as lack of education in rural areas according to distribution in the study area than urban. This variation was found to have significant high correlation with the prevalence of goiter.

The study indicated that the level of knowledge and awareness among the general population about goiter disease (sign and symptoms, causative agent) is high (63%), 92.5% of them said that goiter is an enlargement of thyroid gland and (65.2%) said that iodine deficiency is the common cause of goiter. Such finding is found to be positively associated with the problem in the study area ($P < 0.05$).

The study found that the knowledge of population varied about the sources of iodine, (37.8%) of them said that food is a common source of iodine, and seas water represents second one (30.6%) this explaining the lack of information about iodine due to lack of education.

The study also demonstrated that most of them have good knowledge about foods that contain iodine. 70.1% of them consider that fish is the most common food with high iodine than other foods such as milk (15.3%) and eggs (9.5%). This is agrees with the study of Johnson (2003), and this finding was found to be statistically highly significant with the problem in the study area ($P < 0.05$).

The study also showed that goiter was common as an iodine deficiency disorder known by the majority of population (75.5%), and only (1.7%) had no knowledge about IDD or its biological consequences. This information was obtained from television and radio 34.8% and 33.3% respectively as a sources of information.

The prevalence of all grades of goiter in Sudan was found to be 38.8% overall and ranged from 12.2% in Omdurman to 77.7% in Kosti city, as described by Abdel Monim,(et al, 2011). This study showed that goiter prevalence was found to be (18%), (5.3%) of them in Hajar Elassal, (4.9%) Kaboshia, (4.2%) rural area and (3.6%) in urban, which is considered as endemic goiter, because it is greater than endemicity limit (more than (10%) compared with goiter prevalence in El-figaga area which is (11.9%) estimated by (Elamin, 1998).

Goiter distribution according to age varied with different age groups, but the age group 31-45 years was found to be most common one, this finding is in agreement with Elamin, (1998).

Furthermore, Elamin (1998) added that goiter was commonly more prevalent among females than males with a ratio of 5:1 approximately. Results of this study showed that the majority of goitrous were females (75.7%), against (23.3%) of males. This is in agreement with which was stated by (Hetzel, et al, 2009), which describe that the girls have a higher prevalence than boys.

Grading of goiter was done according to the criteria recommended by the joint WHO/UNICEF/ ICCIDD into three categories, grade 0 (No palpable or visible goiter), grade I (A mass in the neck consistent with an enlarged thyroid that is palpable but not visible when the neck is in normal position. It moves upward in the neck as the subject swallows), and grade II (A swelling in the neck that is visible when the neck is in a normal position and is consistent with an enlarged thyroid when the neck is palpated). The study reveled that grade II was common one of the categories which represent half of goiterous subjects. This study indicated no impact in reduction of prevalence of goiter, rather than slight increase in district study area.

The study demonstrated that most of study population used a preventive measures (72%), (78.3) of them used Oral iodide while only (7.2%) use Iodized salt. This few percent may contribute in the increasing of prevalence of goiter because the Universal salt iodization is the most effective way to achieve the virtual elimination of IDD according to WHO and UNICEF Joint Committee recommendation (WHO, 2007).

Drinking water generally provides about ten percent of the Recommended Dietary Allowance (RDA) which is 150 μg per day for iodine. However, in regions dependent on the local environment for food, and without adventitious or iodine supplementation, drinking water can provide more than twenty percent of the daily iodine intake. (Johnson,2003).This study described that the deep bore wells represented the common source of drinking water used in study population (71.7%), and surface water represent few ones. This may reduce the iodine intake in the population so lead to iodine deficiency disorder. This agrees with (Fordyce, 2003), who reported that content of drinking water from <0.1 to 150 μg/l, an average for all results being 4.4 μg/l. Those studies have looked at drinking waters from a number of sources suggest artesian or deep water well supplies are most enriched in iodine. The general level of iodine reported in natural surface waters (rivers and lakes) ranges from 1–10 μg/l. (Johnson, 2003).

Nile-food is the most enriched source of iodine in the diet with levels in fish averaging 1000–2000 μg/kg (fresh weight) which is some forty times richer in iodine than most other food stuffs, (Johnson, 2003). The study found that fish intake which stated as a rich source of iodine is more frequently (58%) of goitrous. Most of them were taking it once per month, while other goiterous (42%) they had not took fish because it is very expensive for most of them, such finding was found to be have a correlation between fish intake and goiter prevalence.

The levels of iodine in milk, eggs and meat are further raised by adventitious sources added during food production. This iodine is introduced to the food for reasons other than supplementation. The study showed that the majority of populations were taking eggs (87%), weekly, and (13%) do not. Johnson, 2003 add iodine levels in milk are high, because of the use of ionospheres as antiseptic cleansing agents in milk production. In developed countries, cow's milk is the major contributor to dietary iodine exposure. The study reveled that most of goiterous took milk which represent at (94%). This finding is agreement with the fact that the problem may not be due to deficient nutritional iodine as stated by Elamin (1998).

Adequate iodization of all salt will deliver iodine in the required quantities to the population on a continuous and self-sustaining basis. The study demonstrated that (60%) of population had no knowledge about iodized salt, while other (40%) had knowledge. Most of them were taking iodized salt irregularly. This finding was shown to have very strong correlation with goiter prevalence.

Regarding the availability of iodized salt, the study reported that (21.1%) of them thought that it was available. (51.6 %) of respondent stated that it was not available. This is indicate absence of national policies that support using iodized salt in place.

The study revealed that only (20%) of community were using iodized salt continuously, while most of them (61.4%) were not using it, this is because their knowledge was poor.

Although 40% of population had heard of iodized salt, (48%) of them knew that iodized salt is necessary to alleviate IDD, and inspite of that they did not used to consume iodized salt.

5.2 **Conclusion**

From the study we conclude the following:

- The prevalence of goiter among population in the study area was found to be (18%).
- The study described that the deep bore wells represented the common source of drinking water used by study population (71.7%), and surface water represent (18.7%), and both are of low iodine content.
- The study indicated that the level of knowledge and awareness among the general population about goiter disease is high (63%).
- The study demonstrated that the knowledge of population about iodized salt was poor.
- The study revealed that only (20%) of community were using iodized salt continuously. while most of them did not use it.
- Only (48%) of population knew that iodized salt is necessary to alleviate iodine deficiency disorder.
- Goiter was more prevalent among age group (31-45) which represents (43,5%) of goiterous. Also high prevalence among female than male with a ratio of 3:1.
- Most of population were taking fish once per month, while other goiterous were not taking fish because it was very expensive for most of them, such finding was found to have strong correlation with goiter prevalence.

5.3 Recommendation

From the finding of the present study the following recommendations could be suggested:

- The ministry of health should take action for regular monitoring of the iodized salt and education of its nutritional value in the prevention of IDD.
- The locality of shendi must to renewed efforts to reinforce focus on rural and remote tribal areas where sale of non-iodized salt is common.
- The ministry of health should activate the education and communication strategies to community and different stakeholders are essential to communicate the messages on iodine nutrition are equally essential for sustainability.
- The ministry of heath should take action through intervention strategies, extensive nutrition, and health education to support the problem with specific program to strengthen iodine supplementation and the role of national and non-governmental organization.
- The university of Shendi should participate through work shops , lectures , and health programs to aware population about importance of iodine and hazardous of it's deficiency.
- The university of Shendi should conduct further studies on goitrogenic substances which may be associated with public health problems, both diet and water.

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Appendix 1

بسم الله الرحمن الرحيم

University of Shendi

Faculty of Graduate Studies and Scientific Research

Questionnaire to identify the prevalence of goiter among population in.

Shendi locality-River Nile State- Sudan

1- survey date :…………………………serial number………..……………

2- Administrative units:…………………………………………………....

3- Fathers occupation:

a- farmer ( ) b- laborer ( ) c- Employee ( ) d- other ( )

4- Mothers occupation:

a- farmer ( ) b- laborer ( ) c- Employee ( ) d- house wives ( )

5- Monthly Income level:

a) less than 500 pound ( ) b) 501-1000 ( ) c) Above 1000 ( )

6- Father educational level:

a) Illiteracy( ) b) khalwa( ) c) primary school ( )

d) High secondary school ( ) e) universal ( )

7- Mothers educational level:

a) Illiteracy( ) b) khalwa( ) c) primary school ( )

d) High secondary school ( ) e) universal ( )

8-Family size :

a) less than 6 ( ) b) 6-9 ( ) c) Above 9 ( )

9- Knowledge of goiter ?

a) yes ( ) b) No ( )

10- definition of goiter?

a) enlargement of thyroid gland ( ) b) don't know ( )

11-Causative agent of goiter disease:

a) decrease of iodine ubtake ( ) b) other causes ( )

12- Knowledge of respondents about iodine:

a) yes ( ) b) No ( )

13- Knowledge of respondents about definition of iodine :

a) Chemical element ( ) b) Chemical compound ( ) c) Don't know ( )

14- sources of iodine :

a) seas water ( ) b) Soil ( ) c) Food ( ) d) don't know ( )

15- Knowledge of respondents about food contain iodine:

a) yes ( ) b) No ( )

16- Types of foods contain iodine:

a) Fish ( ) b) Milk ( ) c) eggs ( ) d) don't know ( )

17- ***Knowledge of respondents about the most disorder of iodine deficiency***

a) goiter( ) b) Mental retardation ( ) c) Abortion ( )d) don't know( )

18- sources of information :

a) Television ( ) b) Radio ( ) c) Reading ( ) d) lectures( ) e) other( )

19- Prevalence of goiter disease among house holds:

a) yes ( ) b) No ( )

20- Distribution of persons among family members who have goiter:

a) Father ( ) b) Mother ( ) c) Daughters ( )

21- Distribution of age among persons who have goiter :

a) less than 15 year ( ) b) 16 – 30 year( ) c) 31 – 45 year ( )

d) above 45 year ( )

22- gender :

a) male ( ) b) female ( )

23- grade of goiter among persons who have goiter :

a) in visible ( ) b) palpable ( ) c) visible ( ) d) large ( )

24- Application of preventive measures by affected persons:

a)Applied ( ) b) not applied ( )

25- if yes what the type of preventive measures:

a)oral iodine( )b) injection iodide( ) c) iodized salt( ) d) Food contain iodine( )

26- Time detection of goiter disease among affected population:

a) through this month ( ) b) Before six month ( ) c) Before year ( ) d) more than year ( )

27- Sources of drinking water:

a) deep bore wells ( ) b) source wells ( ) c) River Nile ( )

28- Fish intake :

a- intake ( ) b- Not intake ( )

29- Regulation of fish intake:

a) daily ( ) b) weekly ( ) c) monthly ( )

30- Reasons behind not fish intake:

a-Expensive( ) b- not of values ( ) c- undesirable ( )

31- Eggs intake:

a- intake ( ) b- Not intake ( )

32-Regulation of eggs intake:

a) daily ( ) b) weekly ( ) c) monthly ( )

33- Milk intake?

a- intake ( ) b- Not intake ( )

34-Regulation of milk intake:

a) daily ( ) b) weekly ( ) c) monthly ( )

35- Knowledge of respondent about iodized salt?

a)Yes ( ) b- no ( )

36- availability of iodized salt in shendi markets:

a) Available ( ) b) Not available ( ) c) don't know ( )

36- consumption of iodized salt:

a) daily ( ) b) weekly ( ) c) monthly ( )

37- do you think the iodized salt is necessary ?

a) yes ( ) b) No ( )

ملحق رقم 2

بسم الله الرحمن الرحيم

جامعة شندي

كلية الدراسات العليا والبحث العلمي

إستنيان حول إنتشار تضخم الغدة الدرقية لدي المجتمع بمحلية شندي- ولاية نهر النيل- السودان

1- التاريخ:...الرقم المتسلسل..

2- إسم الإدارية...

3- مهنة الأب:

أ/ مزارع ( ) ب/ عامل ( ) ج/ موظف ( ) د/ أخري حدد ( )

4- مهنة الأم:

أ/ مزارع ( ) ب/ عامل ( ) ج/ موظف ( ) د/ أخري حدد ( )

5- مستوي الدخل الشهري:

أ/ أقل من 500 جنيه ( ) ب/ 500 - 1000 جنيه ( ) ج/ أكثر من 1000جنيه ( )

6- المستوي التعليمي للأب :

أ/ أمي ( ) ب/ خلوة ( ) ج/ إبتدائي ( ) د/ ثانوي ( ) ه/ جامعي ( )

7- المستوي التعليمي للأم :

أ/ أمي ( ) ب/ خلوة ( ) ج/ إبتدائي ( ) د/ ثانوي ( ) ه/ جامعي ( )

8- عدد أفراد الأسرة:

أ/ أقل من 6 نسمة ( ) ب/ من 6 - 9 نسمة ( ) ج/ أكثر من 9 نسمة ( )

9- هل تعرف مرض تضخم الغدة الدرقية؟

أ/ نعم ( ) ب/ لا ( )

10- إذا كانت الإجابة نعم فما هو:

أ/ زيادة في حجم الغدة الدرقية ( ) ب/ نقصان في حجم الغدة الدرقية ( ) ج/ لا أعرف ( )

11- ما هو سبب الإصابة بتضخم الغدة الدرقية ؟

أ/ نقص اليود في الغذاء ( ) ب/ عدم تناول الأغذية المحتوية علي اليود بصورة كافية ( )

ج/ أسباب أخري حدد ( )

12- هل تعرف اليود؟

أ/ نعم ( ) ب/ لا ( )

13- إذا كانت الإجابة نعم فما هو؟

أ/ عنصر كيميائي ( ) ب/ مركب كيميائي ( ) ج/ أخري حدد ( )

14- ما هي مصادر اليود ؟

أ/ مياه البحار ( ) ب/ التربة ( ) ج/ الأغذية ( ) د/ أخري حدد ( )

15- هل تعرف الأغذية التي تحتوي علي اليود؟

أ/ نعم ( ) ب/ لا ( )

16- إذا كانت الإجابة نعم فما هي؟

أ/ الأسماك ( ) ب/ الألبان ( ) ج/ البيض ( ) د/ أخري حدد ( )

17- ماذا يسبب نقص اليود ؟

أ/ تضخم الغدة الدرقية ( ) ب/ التخلف العقلي ( ) ج/ الإجهاض ( ) د/ لا أعرف ( )

18- من توصلت إلي هذه المعلومات؟

أ/ التلفزيون ( ) ب/ الراديو ( ) ج/ القراءة ( ) د/ المحاضرات والندوات ( ) ه/ أخري حدد ( )

19- هل أصيب أحد أفراد الأسرة بتضخم في الغدة الدرقية ؟

أ/ نعم ( ) ب/ لا ( )

20- إذا كانت الإجابة نعم فمن هو ؟

أ/ الأب ( ) ب/ الأم ( ) ج/ الأب والأم ( ) د/ أحد الأبناء ( )

21- عمر المصاب:

أ/ أقل من 15 سنة ( ) ب/ من 16-30 سنة ( ) ج/ 31-45 سنة ( ) د/ أكثر من 45 سنة( )

22- جنس المصاب:

أ/ ذكر ( ) ب/ أنثي ( )

23 ما هو مستوي تضخم الغدة الدرقية (للباحث)؟

أ/ غير ظاهرة ( ) ب/ محسوسة ( ) ج/ مرئية ( ) د/ كبيرة الحجم ( )

24- هل تناول المريض أي نوع من الوقاية ؟

أ/ نعم ( ) ب/ لا ( )

25- إذا كانت الإجابة نعم ما نوع الوقاية ؟

أ/ يود عن طريق الفم ( ) ب/ يود عن طريق الحق ( ) ج/ ملح ميودن( )

د/ تناول أغذية تحتوي علي اليود ( )

26- متي أكتشف المريض تضخم الغدة الدرقية لأول مرة؟

أ/ خلال هذا الشهر ( ) ب/ قبل ستة أشهر ( ) ج/ قبل سنة ( ) د/ قبل أكثر من سنة ( )

27- مصادر مياه الشرب ؟

أ/ أبار إرتوازية ( ) ب/ أبار سطحية ( ) ج/ نهر النيل ( ) د/ أخري حدد ( )

28- هل تتناول الأسرة كمية كافية من الأسماك؟

أ/ نعم ( ) ب/ لا ( )

30- إذا كانت الإجابة السابقة نعم كم مرة يتم الإستهلاك:

أ- يوميا ( ) ب- أسبوعيا ( ) ج- شهريا ( )

31- إذا كانت الإجابة السابقة لا ما هو السبب ؟

أ/ غالي الثمن ( ) ب/ ليس له قيمة غذائية ( ) ج/ لا نحبه ( ) د/ أخري حدد ( )

32- هل تتناول الأسرة كمية كافية من البيض ؟

أ/ نعم ( ) ب/ لا ( )

33- إذا كانت الإجابة نعم كم مرة يتم الإستهلاك؟

أ-يوميا ( ) ب- أسبوعيا ( ) ج- شهريا ( )

34- هل تتناول الأسرة كمية كافية من الألبان ؟

أ/ نعم ( ) ب/ لا ( )

35- إذا كانت الإجابة نعم كم مرة يتم الإستهلاك؟

أ-يوميا ( ) ب- أسبوعيا ( ) ج- شهريا ( )

36- هل تعرف شيء عن الملح الميودن؟

أ-نعم ( ) ب- لا ( )

37- - هل الملح الميودن متاح في محلية شندي؟

أ- متاح ( ) ب- غير متاح ( ) ج- لا أعرف ( )

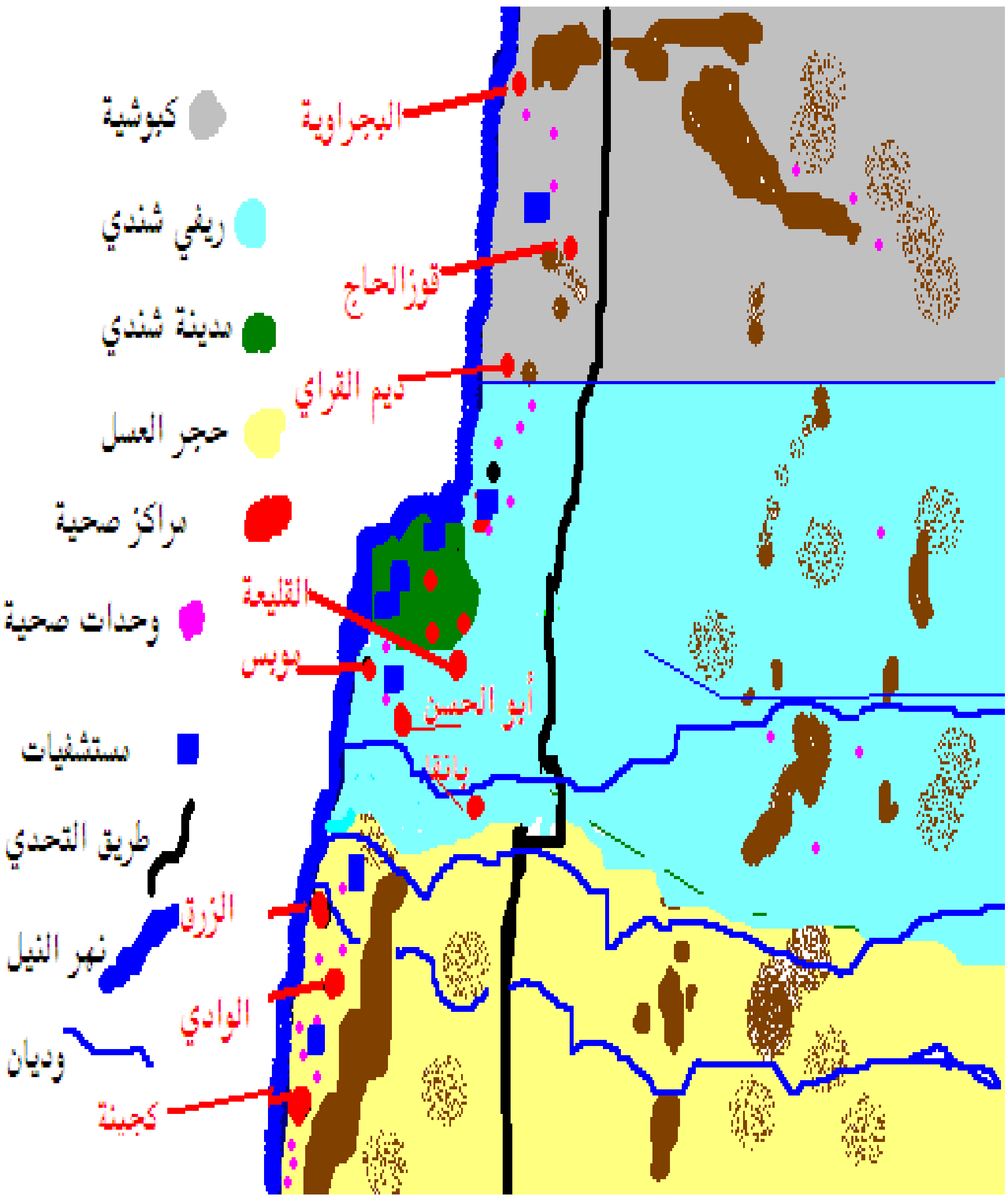
38- إذا كانت الإجابة نعم كم مرة يتم إستهلاكه:

أ--يوميا ( ) ب- أسبوعيا ( ) ج- شهريا ( )

39- هل تعتقد أن الملح الميودن ضروري؟

أ-نعم ( ) ب- لا ( )

Appendix 4: Map of Shendi locality (study area):



Appendix 5: New iodized salt packages produced in Port Sudan

Appendix 6: Hussain Al Jawarana of ICCIDD demonstrates quality control measures during training of Sudanese salt producers on proper salt iodization

Appendix 7: Increase coverage of the population with adequately iodized salt.

Appendix 8:Millions of Chinese children learn better at school because of iodized salt