بسم الله الرحمن الرحيم

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Assessment of Mercury level in Blood Samples among Sudanese Workers in Alabeedya Traditional Gold Mining Area, River Nile State, Sudan October2019 – March2020 .

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In The Partial Fulfillment of the Requirements For The Degree of

Master of Science in Analytical Chemistry

By

Dalal Osman Morsi Mahmoud

Supervisor

Prof. Mutasim Elhag Elhussien

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بسم الله الرحمن الرحيم

الآيــــــة

وَالأَرْضَ مَدَدْنَاهَا وَأَلْقَيْنَا فِيهَا رَوَاسِيَ وَأَنبَتْنَا فِيهَا مِن كلِّ شَيْء مَّوْزُونٍ(19)

صدق الله العظيم

سورة الحجر(الآية 19)

Dedication

To the soul of my dear father, to my dear mother God give her a long life, my brother and to my sisters whom supported me to continue, to my dear husband who encourage me by all his possession To my dear kids (Rseel, Ramah and Rawan) god bless them and save and to everyone who helped me.

Acknowledgment

Great thanks to Allah the Lord of the universe for giving me assistance, ability and patience to fulfill this work.

I would like to express my deep and sincere gratitude to professor. **MutasimElhussien** for his valuable supervision and guidance. As supervisor, his insight, observations and suggestions helped me to establish the overall direction of the research and to achieve the objectives of the work. prof. Elhussien's continuous encouragement and support had always been a source of inspiration and energy to me.

Finally, I am forever indebted to my small and big family for their encouragement since the beginning of this research

Abstract

Mercury is one of the major heavy metals that can cause harm to the human body throughout exposure. In this study a sensitive enough Inductive Coupled Plasma Emission technique was used to quantify total mercury levels in blood serum of traditional gold miner worker in Alabeedya area, River Nile State – Sudan, during October 2019 – March 2020. Seventeen samples concentrations were determined according to four different exposure compared to a control one. The obtained results showed that, the highest level of total mercury 7025 μg/l, in burning workers, while concentrations of 3675μg/l , 1682 μg/l and 797.5 μg/l, were determined in washings ,workers in shops and Mills respectively compared with 29.0μg/l for the reference sample and 10 μg/l WHO reference . The study also showed a relationship between total mercury concentration and staying limits as in the gold mining area to find incidents of neurological symptoms headache feeling stress, feeling weakness and Eye problems .The exposure resulting from inappropriate using of mercury. This study indicated that, the gold miners in Alabeedya area had been exposed to high levels of mercury.

المستخلص

الزئبق هو أحد المعادن الثقيلة الرئيسية التي يمكن أن تلحق الضرر بجسم الإنسان طول فترة التعرض له. في هذه الدراسة، تم استخدام تقنية انبعاث البلازما المقترنة الحساسة بدرجة كافية لقياس مستويات الزئبق الكلية في عمال التعدين التقليدي للذهب في منطقة العبيدية ،ولاية نهرالنيل - السودان، خلال شهر أكتوبر 2019 - مارس 2020م. تم تحديد سبعة عشر عينة تركيز توافق أربعة عينات مختلفة للتعرض مقارنة مع عينة مرجعية.
وأظهرت النتائج المتحصل عليها أن أعلى مستوى تركيز للزئبق الكلي 7025 ميكروغرام / لترفي العمال الذين يعملون في الحريق، بينما تم تحديد التراكيز 3675 ميكروغرام / لترو1682 ميكروغرام / لتر 797.5 ميكروغرام / لتر و في العمال الذين يعملون بالغسيل والعاملين في المحلات والطواحين على التوالي مقارنة بـ 29.0 ميكروغرام / لتر للعينة المرجعية و10 ميكروغرام / لتر الحد الاقصي لمنظمة الصحة العالمية .
أظهرت هذه الدراسة أيضًا وجود علاقة بين تركيز الزئبق الكلي وفترة البقاء للعمال في منطقة تعدين الذهب كما تم العثور على أعراض عصبية وصداع وشعور بالتوتر والشعور بالتعب ومشاكل في العيون ذلك للتعرض الناتج عن الاستخدام غير الملائم للزئبق . أشارت هذه النتائج إلى تعرض عمال التعدين التقليدي للذهب في منطقة العبيدية لمستويات عالية من الزئبق .

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Chapter One

Introduction

1.1 Background:

Mercury concentration in the blood is one of mercury exposure biomarkers. Detection of mercury in biological samples such as blood, urine and hair samples. This study conducted in Alabeedya mining area in River Nile State, Sudan, during the period from October 2019 to March 2020 . The aim of the study is to evaluate serum mercury levels in traditional gold miners. The study include two subjects, one of them who working in the gold mining area, beside healthy volunteer from Atbara City, River Nile State, as control Sample .

1.2 General Introduction:

The first mining boom episode in Sudan gold, iron ore and copper mining activities in Nubia since 3000-1500 BC million miners participated, with 4 million family dependents benefited from mined gold revenues. The traditional gold mining activities cover 14 of the 18 Sudanese states. In 2014, the government produced over 60 tons of gold, which make Sudan ranked Africa’s third-largest gold miner, and pushed it into the top 15 global producers [1,3] With recent estimates indicating there are as many as 19 million artisanal small gold (ASGM)miners[4, 5] mercury use and emissions in ASGM is clearly a global health problem [6].The heavy metals cadmium, lead, and mercury are common air pollutants emitted. Occupational mercury intoxication occurred frequently in the workers of the hat manufacturing factories of Europe in the nineteenth century. Mainly as a result of various industrial activities. Mercury vapor can elicit the nephritic syndrome, characterized by excessive loss of protein (mainly albumin) in the blood, and edema[7,8].

Mercury-based artisanal and small-scale gold mining (ASGM) causes more mercury pollution than any other human activity [9]. mercury metal is used to extract gold from ore as a stable amalgam, The amalgam is then heated to evaporate the mercury and isolate the gold. While mercury amalgamation has been used for thousands of years to mine gold and silver[10]. it is unfortunately.

1.3 Rationale and Objectives

Rationale traditional gold mining using mercury to form gold amalgam is widely used in South America, Africa, and Asia. Many studies had assessed the mercury level, determined health effects, and investigated the health risk due to its exposure worldwide. In Sudan, the gold mining activities are spread However, there is only a few studies covering this area So, this study can conduct .

1.4 General Objective

To Assessment mercury levels in the blood among Sudanese traditional gold mining workers in Alabeedya .

1.5 Specific objective

• To detect mercury exposure among miners and a non-miner as reference.

• To measure the concentration of mercury in blood among gold mining worker.

• To observe the general toxicity among the gold mining worker.

• To observe the health effect of mercury in gold mining worker.

1.6 Mercury Behavior

Mercury is a chemical element with the symbol Hg and atomic number 80. It is commonly known as quicksilver and was formerly named hydrargyrum [11] Mercury is a heavy, silvery-white liquid metal compared to other metals, it is a poor conductor of heat, but a fair conductor of electricity It has a freezing point of −38.83 C° and a boiling point of 356.73 C° [12, 13, 14] both the lowest of any stable metal, although preliminary experiments on Copper Znic and iron have indicated that they have even lower boiling points copper Znic being the element below Mercury in the periodic table, following the trend of decreasing boiling points down group [15].

1.6.1 Chemical properties

Mercury does not react with most acids, such as dilute although oxidizing acids such as concentrated sulfuric acid and nitric acid or regain dissolve it to give sulfate, nitrate ,and chloride. Like silver, mercury atmospheric hydrogen sulfide. Mercury reacts with solid sulfur flakes, which are used in mercury spill kits to absorb mercury (spill kits also use activated Carbon and powdered Zinc)[16].

Mercury dissolves many metals such as gold and silver to form amalgams. Iron is an exception, and iron flasks have traditionally been used to trade mercury. Several other first row transition metals with the exception of Manganese, Copper and Zinc are also resistant in forming amalgams. Other elements that do not readily form amalgams with mercury include platinum[17].

Mercury (Hg) is a naturally occurring element found in air, water, and soil. It is distributed throughout the environment by both natural and anthropogenic (human) processes.

The three predominant forms include elemental mercury (with the chemical symbol of Hg), ionic mercury (also known as inorganic mercury with the chemical symbol of Hg (II) or Hg^{2+}) which in nature exists as Hg (II) mercuric compounds or complexes in solution, and organic mercury with methyl mercury (with the chemical symbol of MeHg) being the most important, while most of the mercury in water, sediments, soil, plants and animals as found inorganic and organic forms of the element.

These forms all have different toxicities and implications for health and measures to prevent exposure[18]. Elemental mercury is a liquid that vaporizes readily it can stay for up to a year in the atmosphere, where it can be transported and deposited globally. It ultimately settles in the sediment of lakes, rivers or bays where it is transformed into methyl mercury, absorbed by phytoplankton, ingested by zooplankton and fish, and accumulates especially in long-lived predatory species, such as shark and swordfish[19].

1.6.2 Exposure to mercury

All humans are exposed to some level of mercury. Most people are exposed to low levels of mercury, often through chronic exposure (continuous or intermittent long term contact). However, some people are exposed to high levels of mercury, including acute exposure (exposure occurring over a short period of time, often less than a day). An example of acute exposure would be mercury exposure due to an industrial accident. Factors that determine whether health effects occur and their severity include, the type of mercury concerned, the dose, the age or developmental stage of the person exposed (the fetus is most susceptible), the duration of exposure, the route of exposure (inhalation, ingestion or dermal contact).

Mercury is considered as one of the toxic and dangerous heavy metals [20], Hg can easily accumulate in the food chain and reaches to the human body through ingestion pathway and can also easily enter in to human body through inhalation and others routes and causes harmful effects on human health [21].

The metal is still widely used in many areas, including making thermometers, barometers, manometers, whitening cosmetics, and dental amalgam cultural and religious practices in some cultures, mercury is believed to chase away evil spirits when placed on the walls of houses. elsewhere, it is thought that mercury-based talismans can bring good luck. Obscure religious practices involving the use of mercury are known, but the topic remains poorly documented [22].

1. 6.3 Isotopes oF Mercury

There are seven stable isotopes of mercury, with 202 Hg being the most abundant (29.86%). The longest-lived radio isotopes are 194 Hg with a half-life of 444 years, and 203 Hg with a half-life of 46.612 days. Most of the remaining radioisotopes have half-lives that are less than a day. 199 Hg and 201 Hg are the most often studied NMR-active nuclei, having spins of 1⁄2 and 3⁄2 respectively[16].

1.6.4 Mercury releases

Natural: volcanic activity, weathering of rocks, water movements, biological processes. Human activities. combustion of fossil fuels (specially coal), electricity-generating power stations, gold and mercury mining, manufacture of cement, pesticides, chlorine, caustic soda, mirrors and medical equipment, industrial leaks, dentistry, waste and corpse incineration.

Remobilization of historic sources, mercury in soil, sediment, water, landfill, waste. I ndustrial use of mercury can result in different patterns of human exposures, including ,occupational exposure of workers in direct contact with either forms of mercury in their workplace. In these cases, assessment of workers' exposure to mercury can be addressed following the guidelines described earlier.

Exposure of populations living near industrial settlements and impacted by releases to air or water and disposal of wastes (effluents, refuses, and landfills). For example, exposures can occur due to mercury releases from mercury-cell chlor-alkali plants. Such releases can lead to elevated mercury exposures for local communities. Therefore, local in depth assessment could be considered a priority and evaluated following the guidelines described in this document [23].

Recently, the issue of mercury toxicity according to the mercury exposure level, health effects as well as the determination of what mercury levels affect health are in the spotlight and under active discussion. Evaluating the health effects and Biomarker of mercury exposure and establishing diagnosis and treatment standards are very difficult.

Chapter two

Literature Review

Many African countries are going through a phase of difficult economic conditions and a high rate of unemployment and poverty in their communities. Over the years artisanal gold mining has been a source of income generation of many communities.

A recent boom in mining is stirring in different parts of the continent where the prospect of mineral resources has already been announced. This is encouraged by governmental authorities and large mining companies, so as to fill the gap in the economy deficit and involve the unemployed. In some areas people holding essential jobs are leaving, attracted by the gold glitter and wealth [24].

In recent years after referendum of Southern Sudan, most of the petroleum income was lost in Sudan, as a result nearly millions of Sudanese were forced to work in artisanal gold mining especially in River Nile State, using traditional means for extracting the gold from ores. This study was done to evaluate the occupational exposure for mercury among these miners.

2.1 Artisanal and Small-Scale Gold Mining (ASGM)

It is an informal economic activity. Most ASGM process of extracting gold ore from the ground in the absence of land rights, mining license, exploration or mining mineral exploration permit or any legitimate document that allows the operation. Its haphazard nature, location close to and dependence on water have negative effects on the physical, chemical and biological composition of water.The socio-economic benefits of small scale mining, which include employment and income generation, are seriously outweighed by devastating environmental costs and impacts.

ASGM covers a broad spectrum of activities which depend on size of work force, timing, methods used to carry out the operations and whether operations are legal, illegal, formal or informal. The mining is done mainly by poverty driven rural individuals, groups, families or cooperatives with minimal or mechanization, knowledge or technology in mining and mining safety. It is commonly associated with informal, unregulated, unregistered, unlicensed, undercapitalized and under-equipped mining operations [25]. Traditional mining artisanal scale mining is defined as an activity practiced by utilizing local traditional means within the specified area.

2.2 Mercury Problem in Artisanal Gold Mining

Mercury-based artisanal and small-scale gold mining (ASGM)causes more mercury pollution than any other human activity [26]. In this practice, mercury metal is used to extract gold from ore as a stable amalgam. The amalgam is then heated to evaporate the mercury and isolate the gold. While mercury amalgamation has been used for thousands of years to mine gold and silver[27] ,it is unfortunately still a widespread technique in present day, artisanal gold mining. Mercury is abundant and inexpensive ,sourced through a variety of industrial supply chains or mined directly from cinnabar, making are daily available tool for mining gold[28]. It is estimated that between410 and 1400 tones of mercury are emitted through ASGM each year , accounting for 37% of global mercury emissions.[29] Driven by rising prices in gold (approximately 40,000 US D k) for most of 2017 [30] , ASGM is wide spread ,with an estimated 10 to 19 million miners working primarily in Asia, Africa and South America As many as mining operations [31].

These miners typically live in improve risked cases, few other opportunities for employment exist in these regions and ASGM is therefore a critical way to sustain their livelihood [32]. These mining activities largely take place in the so-called “informal” economy in which participants operate unlicensed or without legal authorization a reason why effective regulation of mercury emissions is extraordinarily difficult[33]. Never the les ,these artisanal miners contribute substantially to the local and world’s gold So while each individual mining operation may be relatively small, the practice is widespread. Because of the extraordinary amounts of mercury handled directly by the miners and released into the environment, the burden to human health is staggering [34]. Mercury vapor inhaled by miners results in impaired cognitive function, neurological damage, kidney damage and several other health problems[35]. In some cases, amalgams are processed near the home or in gold shops in villages or cities, so the mercury vapor generated in the process affects non-miners living in these areas For children and fetuses, exposure to mercury pollution is especially dangerous as it increases the likelihood of physical deformities, neurological damage and lower IQ[36]. These risks of mercury exposure are also compounded by the high levels of mercury that accumulate in fish and other food supplies in ASGM communities [37] .

The mercury problem in ASGM is a growing crisis in environmental and human well-being. Rightfully, the issue has garnered attention in both the scientific[38] and general news media as ASGM becomes more prevalent and its effects more visible .The damage to cognitive and neurological function of the miners , the physical and mental disabilities prevalent in children near ASGM communities are startlingly clear in these reports[39] . Furthermore, the wider damage to the environment and the transport of high levels of mercury to sites beyond the mine have in some cases, led to national conflict and military intervention. The time to address this problem is now. On August 16th 2017, the Minamata convention on mercury was ratified by more than 50 parties to the treaty [40].This milestone brought into force the most comprehensive effort to control the trade, use and emissions of mercury. As ASGM is the largest source of mercury pollution worldwide, reforming this sector is a priority of the Minamata Convention Accordingly, the convention requires signatories to "take steps to reduce, and where feasible eliminate ,the use of mercury and the emissions and releases to the environment of mercury from, such mining and processing .There are also specific provisions for member nations to help educate miners and promote research into sustainable, mercury-free mining[41]. In the accompanying Annex of the Minamata convention, further actions are prescribed that include the elimination of four especially problematic activities: whole ore amalgamation, open heating of amalgams, heating amalgams in residential areas, and the use of cyanide to extract gold from mercury-rich tailings. Because these goals will likely require advances in environmental chemistry and innovative extractive technologies, it is worthwhile to consider how the chemistry community might contribute to these global initiatives.

2.3 Mercury Emissions from Artisanal and Small- Scale Gold Mining

In ASGM, the amalgamation process, tailings processing, and gold recovery from the amalgam result in substantial release of mercury into the environment. By some estimates, release of mercury from ASGM exceeds million kg each year [42]. This level of mercury pollution may exceed the combined emissions of coal combustion, cement production, chlor-alkali plant operation, and large-scale industrial mining and metallurgy It is therefore important to look at each stage of common ASGM practices to identify how mercury is released into the environment and mitigate harm. The primary sources of these emissions are from tailings discharge to land and water and mercury gas emissions during amalgam roasting. In the amalgamation process, substantial amounts of mercury can be lost in the tailings. In particular, milling ore and mercury in trammels can result in the formation of tiny mercury droplets that become finely dispersed in the tailings. This “mercury flour” is especially and transported far from the mining site In some cases, mercury-rich tailings can travel in rivers hundreds of kilometers from the mine. The floured mercury is also difficult to recover because it does not coalesce efficiently

2.4 Biological markers

Exposures can be estimated by measuring pollutant levels in various body tissues (such as hair, blood, cord, urine, human milk and nails). These measurements, also known as biological markers (or biomarkers), are useful tools for human exposure assessment. They are sensitive indices of an individual’s exposure to mercury, providing a measure of the internal dose, which can be used to evaluate the likelihood of adverse health effects and improve clinical diagnoses. These biomarkers are useful as surveillance tools for monitoring mercury exposure in individuals and populations. There is a well-established relationship between several biomarkers of mercury exposure and adverse health effects.

2.5 Blood Mercury Concentration

Blood mercury concentrations can be determined by a variety of analytical techniques. Often blood samples are digested with high purity mineral acids and oxidants prior to instrumental analysis. Sample preparation and digestion procedures play an important role in blood sample analysis as the sample matrix can interfere with analysis and lead to inaccurate results.

Blood mercury concentrations rapidly increase immediately after or during brief exposure. Therefore, the measurement also needs to take place right after the exposure However, in cases of those who have been chronically exposed to mercury, blood mercury concentration levels maintained a high level even when the exposure has ceased, due to the heavy burden of mercury on the body [43]. In the meantime, the concentration level of methyl mercury which accounts for the largest share in the blood is known to be linked with the amount of mercury we are exposed to daily, according to the equation Furthermore, although the concentration level of methyl mercury in red blood cells is high in acute poisoning, it varies widely in chronic intoxication. The mercury concentration in whole blood is usually lower than 10 µg/L, but the value of 20 µg/L or below is considered normal. The blood mercury concentration can rise to 35 µg/L after long-term exposure to mercury vapor [44].

A study was conducted in Abuhamed mining area in Sudan , evaluated serum mercury levels in artisanal gold miners using direct mercury analyzer (DMA-80). The study observed significant increase in serum mercury levels in the gold miners, when compared with control group (24.9 ± 32.24µg/l) versus (1.40 ± 0.94µg/l) with P value (0.000). The mean forced expiratory volume in the first second (FEV1) in the gold miners was (3.24 ± 0.57) versus (3.40 ± 0.39) in the control group, while the mean forced vital capacity (FVC) in the mercury exposed miners was (3.7 ± 0.69) versus (3.86 ± 0.60) in non-exposed control group[45] .

A bio monitoring study was carried out to examine the adverse impacts of total mercury in the blood (HgB), urine (HgU) and human scalp hair (HgH) on the residents of a mining district in Colombia. Representative biological samples (scalp hair, urine and blood) were collected from volunteered participants (*n* = 63) to estimate the exposure levels of total Hg using a direct mercury analyzer, while the average geometric mean of total Hg concentrations in the blood of was (10.05 μg/L) [46].

A Study for mercury exposure in gold mining workers in the northwest of Iran in blood and urine were determined using Hydride Generation Atomic Absorption Spectrophotometer (HGAAS) in sixteen gold miners with neuropsychiatric symptoms. The patients treated with two chelating agents, dimercaprol and D- penicillamine. The mean serum mercury levels before and after chelation therapy were 208.14 $\mu g/L^{-1}$ and 10.50 μg/L-1, respectively. The mean urinary mercury levels before and after chelation therapy were 134.70 $\mu g/L^{-1}$ and 17.23 $\mu g/L^{-1}$, respectively. The results of this study showed that there are significant differences between concentration of blood and urine mercury before and after intervention ($p<0.005$). There were no significant differences between in the biochemistry parameters of patients before and after treatment study Mercury exposure of gold mining workers in the northwest of Iran concluded that dermal absorption of elemental mercury is limited by estimating that dermal absorption only contributed2.6% of the absorbed mercury following exposure. Approximately to elemental mercury vapor in the air; the other 97.4% occurred through inhalation. The result of this study showed no significant relationship between amalgam filing and mercury concentration, which is the same as where there is no relationship between mercury concentrations in lower parts of the brain and the number of amalgam fillings in the mouth [47] .

Chapter Three

Material and Methods

3.1 Meterial

3.1.1 Reagents

All analytical grade reagents were purchased from Merck Darmstadt. Deionized (18.2MΩcm^{-1}) water was used throughout the experiments, obtained from lab water purification system (Coupled Plazma emission ICPE9000 in UK).

Nitric Acid.

Water .

3.2 Methods

3.2.1 Study Design

An analytical cross-sectional observational study.

3.2.2 Study Area

The study was carried out in Alabeedya gold mining area, located 18 km from Barber city, Barber locality coordinates:18°01′50″N 33°59′36″ E in River Nile state ,Sudan.

3.2.3 Study Population

The traditional gold miners included in this study, have been in the mining area in the desert, for more than 6 successive months. They were living in small camps nearby working area, which included wells, stone mills, washing and molding.

Scheme (2.1): Rive Nile State

The washing performed in water pools where gold is mixed with mercury and then the mixer heated in small metal pans directly in the air. Bare hands, feet and faces were seen in all the processes. All participants are from Alabeedya gold mining area will be include gold miners who worked in and non-miner from Atbara city as control .

3.2.4 Inclusion Criteria

The study include all participant who completed the questionnaire and gave blood sample N=(Seventeen).

Working in the field of traditional gold mining for not less than 6 months.

3. 2.5 Sample size

Seventeen samples were taken from different workers covering all activities and practices in the mining area:

• Workers in Mercury burning (Four samples)

• Workers in Mills (Four samples)

• Workers in mercury washing (Four samples)

•workers in shops in mining areas (Five samples)

•A sample normal healthy control, from Atbara not work in mining .

3.2.6 Data collection

The questionnaire designed as WHO guideline , Interview questionnaire was conducted with all the participants.

Ethical considerations and Ethical documents were obtained from Omdurman Islamic University- ethical committee.

3.2.7 Collection of Samples

Five ml of blood samples were collected plastic containers. Blood specimens were collected from all the subjects under study in sterile conditions into sterile plain containers and the serum was separated by centrifugation into another plain container, and then stored at -7 C° till the time of analysis in sudanese police forensic Laboratories .

3.2.8 Determination of mercury in whole blood

One ml of serum blood was mixed with 5 ml of nitric acid and kept in a water bath at a temperature of 60 C° for 12-14 hour after the digestion process is complete, the samples was diluted by demonized water to mark 25 ml in volumetric flask and Analyzed by Inductive Coupled Plazma Emission (ICPE9000) .

3.2.9 Preparation of standards

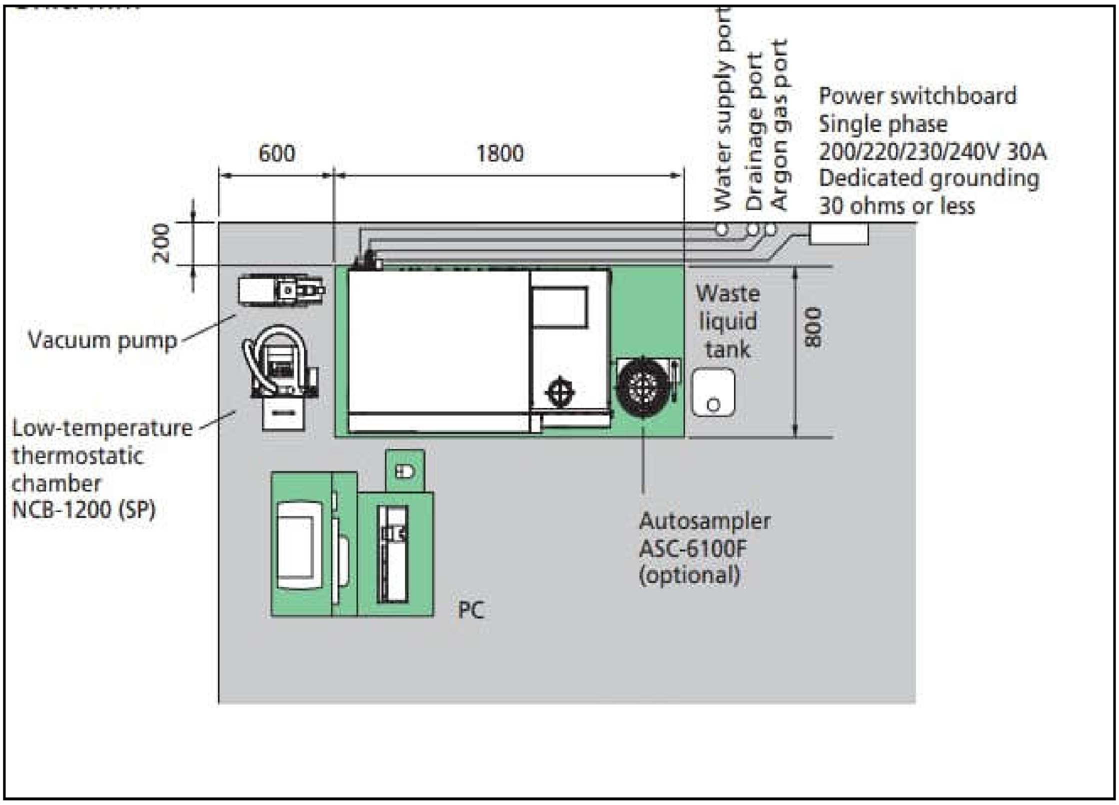
The standard solutions of mercury were prepared by serial dilution from known standard stock solutions of 1000 mg/L. A calibration curve was prepared and then the analysis of the samples for the mercury were done .

3.2.10 Instrumentation Inductive Coupled Plazma Emission instrument (ICPE9000)

ICP emission spectrometers are analytical instruments used in a broad range of fields. They feature are:
high ppb level detection ability, broad 5-6 digit analysis concentration ranges, and batch analysis of multiple elements. Recent wider usage has resulted in an increased demand for shorter analysis times and improved.

- high-matrix sample detection.
- samples can be evaluated in a number of ways.
- The Assistant Function automatically.
- carries out wavelength selection for measured elements and interference correction.
- Simple and accurate measurement is possible even with hard-to-measure high-matrix samples.

Scheme (3.1): Inductive Couple Plazma Instrument(ICPE9000)



Schme (3.2) Inductive Coupled Plazma Instrument Diagram

Figure (3.3): Open Dish for Mercury Washing

Figure (3.4): Mercury Burning in a pan

Figure (3.5): mercury Wet Mills

Figure (3.6): Serum Separation Using Centrifuging

Figure (3.7): Powdering Stones Mills

Chapter four

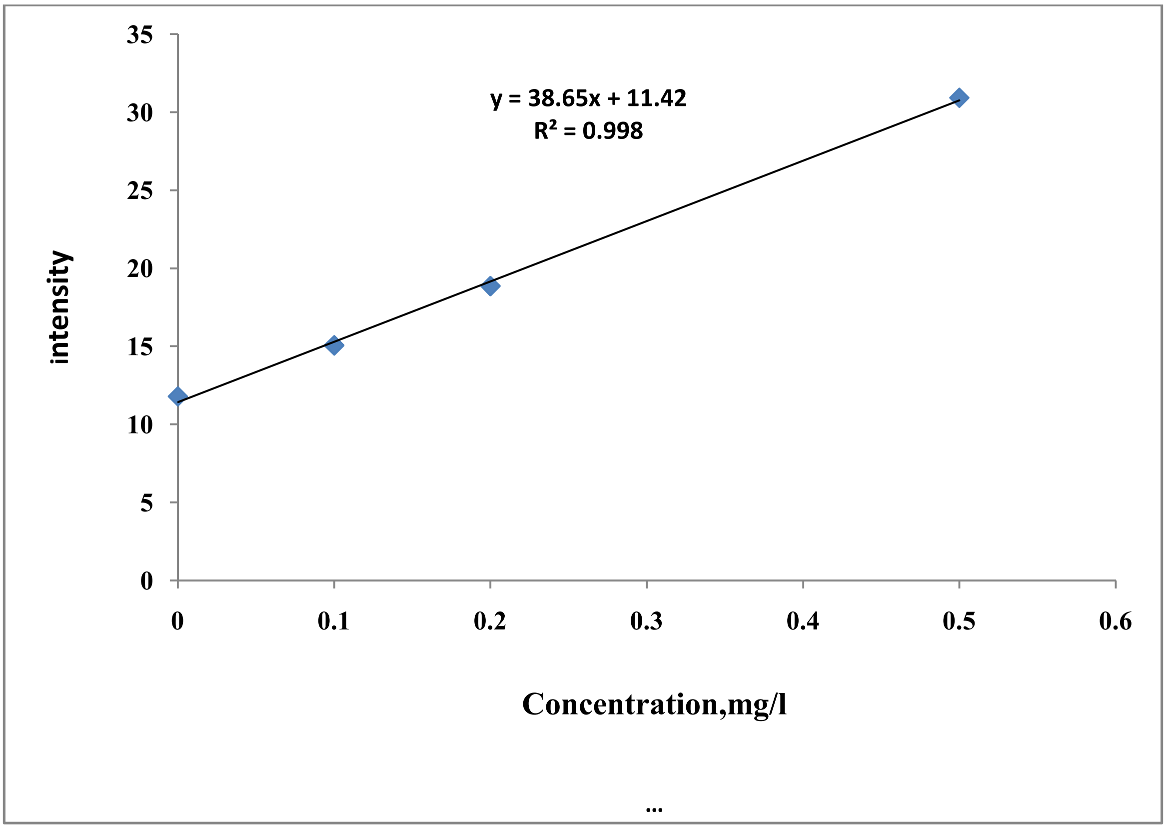
Results And Discusstion

From the stanard solution of mercury (1000 mg/l) for ICPE analysis the obtained results are tabulated in table (4.1). The calibration curve showed a good lineraty with a high regression coefficient

(R^2=0.998) within the range of the studied concentrations, Figure(4.1).

Table (4.1): Standards Solution for Calibration Curve

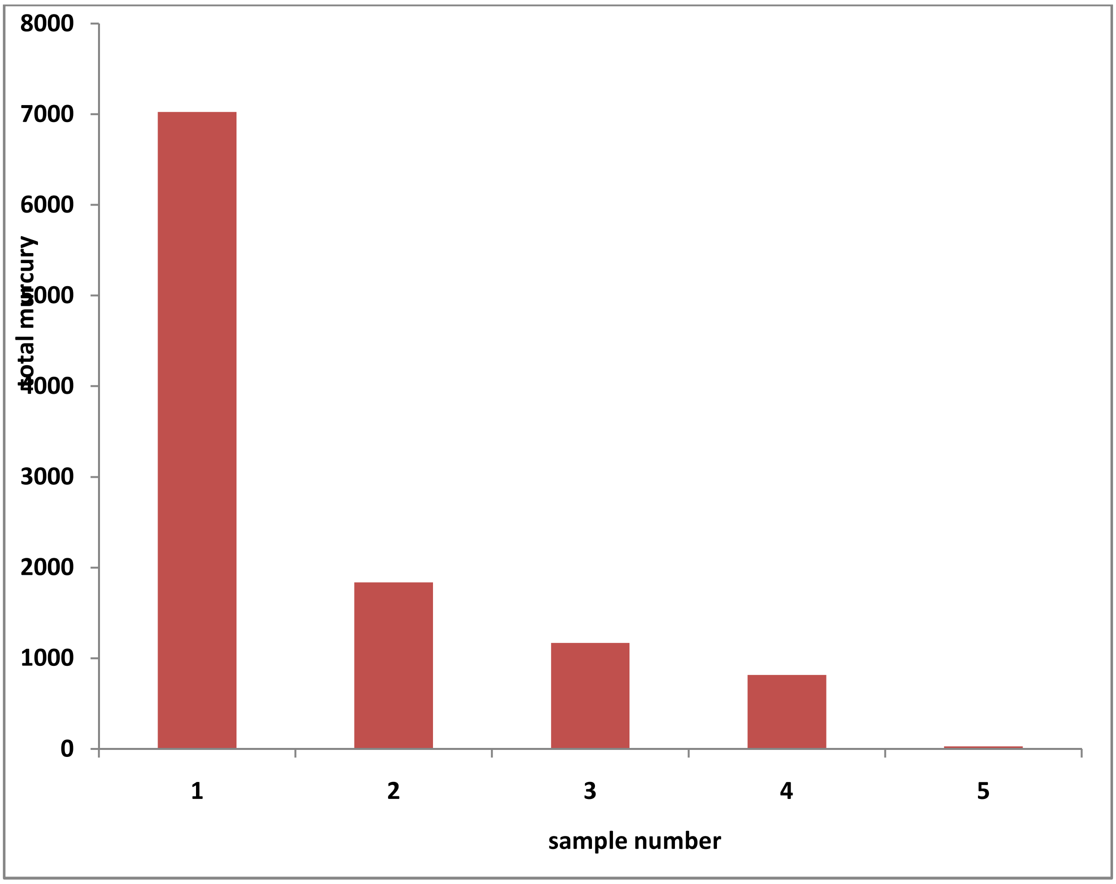
Concentration mg/l	**Intensity**
0.000	11.789
0.1000	15.059
0.2000	18.857
0.5000	30.920



Figure(4.1):Calibration Curve for Standard Mercury Level in Blood Samples using (ICPE9000)

Table (4.2): Total Mercury µg/l in Blood Samples Mercury Burning

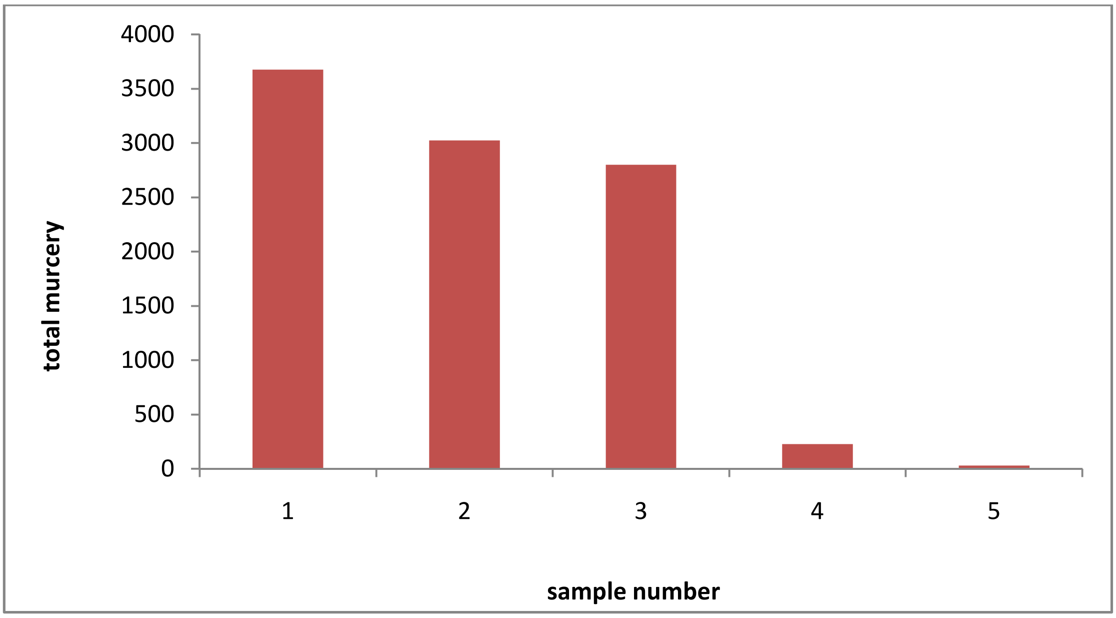
Sample Number	Quant Average mg/L	Total mercury µg/l	Intensity
1	0.2810	7025	22.192
2	0.0735	1837	13.961
3	0.0468	1170	12.902
4	0.0327	817.5	12.343
Reference	0.00116	29.00	11.092



Figure(4.2):Total Mercury µg/l in Blood Samples Mercury Burning

Table(4.3): Total Mercury µg/l in Blood Samples Mercury Washing

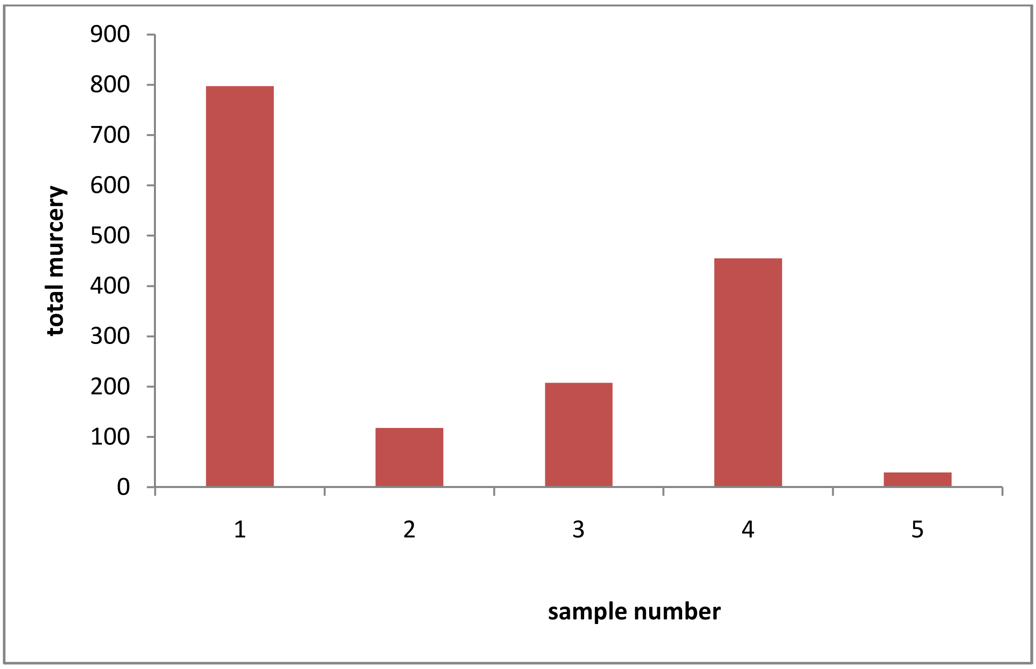
Sample Number	Quant Average mg/L	Total Mercury µg/l	Intensity
1	0.147	3675	16.877
2	0.121	3025	15.845
3	0.112	2800	15.488
4	0.0091	227.5	11.406
Reference	0.00116	29.00	11.092



Figure(4.3): Total mercury µg/l in Blood Samples(Mercury Washing)

Table(4.4): Total Mercury µg/l in Blood Samples Mills

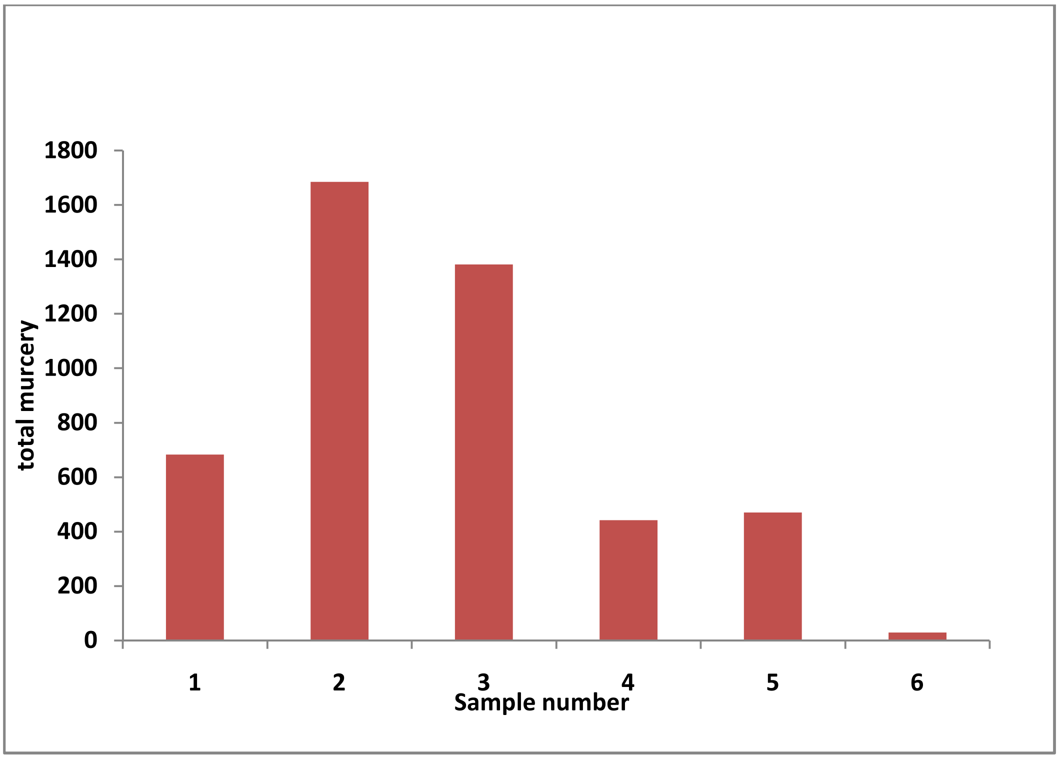
Sample Number	Quant Average mg/L	Total mercury µg/l	Intensity
1	0.0319	797.5	12.311
2	0.0047	117.5	11.232
3	0.0083	207.5	11.375
4	0.0182	455.0	11.767
Reference	0.00116	29.00	11.092



Figure(4.4) : Total Mercury µg/l in Blood Samples(mills)

Table(4.5): Total Mercury µg/l in Blood Samples worker in shops

Sample Number	Quant Average mg/L	Total mercury µg/l	Intensity
1	0.0273	682.5	11.146
2	0.0674	1685	13.719
3	0.0553	1382	13.239
4	0.0177	442.5	11.748
5	0.0188	470.0	11.791
Reference	0.00116	29.00	11.092



Figure(4.5) : Total mercury µg/l in blood samples (worker in shops)

Table(4.6): Total mercury µg/l in blood samples all samples

Sample Number	Quant Average mg/L	Total mercury µg/l	Intensity
1	0.281	7025	22.192
2	0.0735	1837	13.961
3	0.0468	1170	12.902
4	0.0327	817.5	12.343
5	0.147	3675	16.877
6	0.121	3025	15.845
7	0.112	2800	15.488
8	0.0091	227.5	11.406
9	0.0319	797.5	12.311
10	0.0047	117.5	11.232
11	0.0083	207.5	11.375
12	0.0182	455	11.767
13	0.0273	682.5	11.146
14	0.0674	1685	13.719
15	0.0553	1382	13.239
16	0.0177	442.5	11.748
17	0.0188	470	11.791
18	0.00116	29	11.092

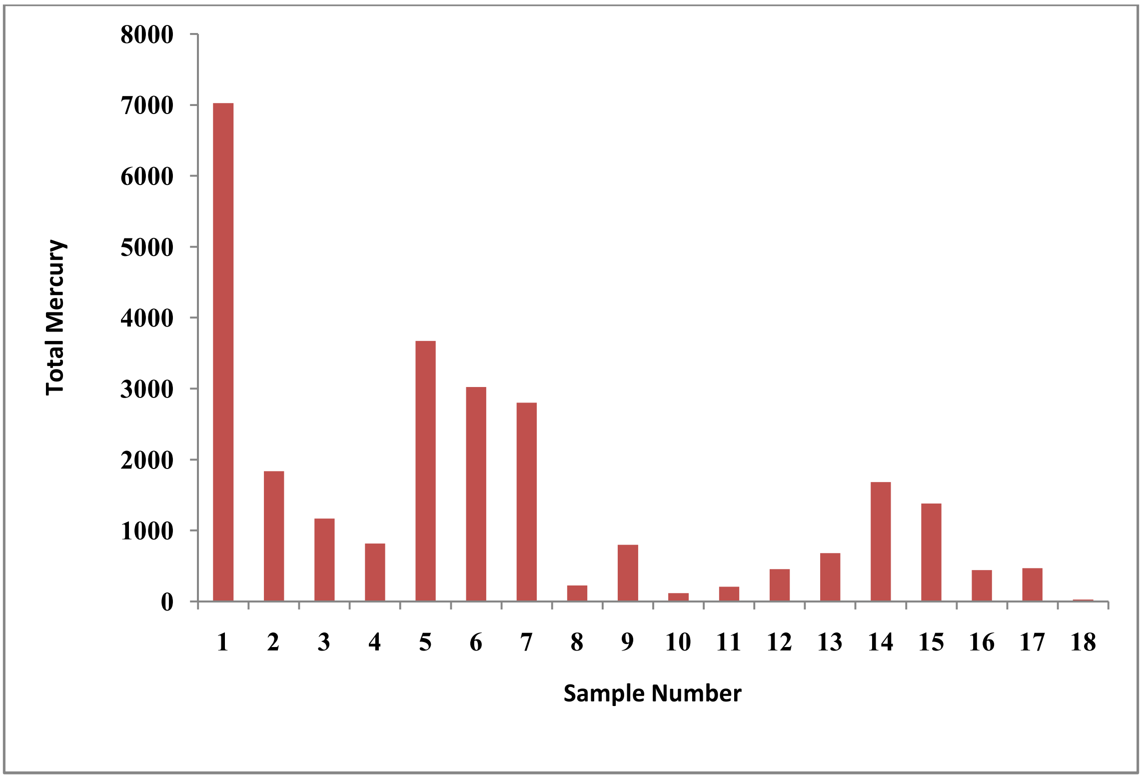
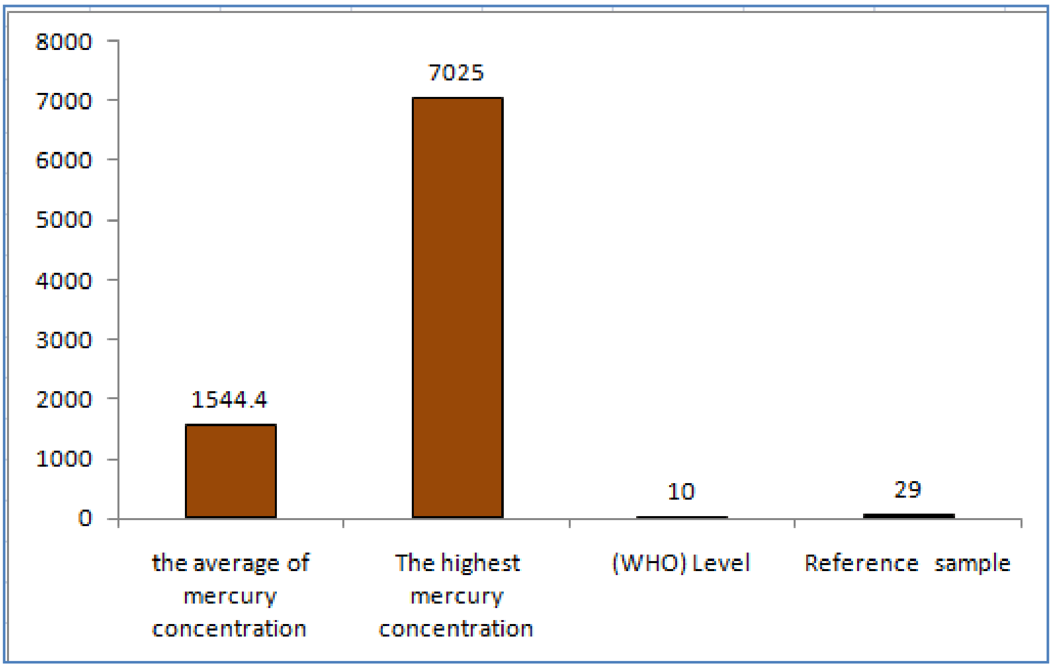


Figure (4.6): Total mercury µg/l in blood samples all samples

Table(4.7): Total Mercury µg/L in blood samples and reference sample .

Matrix	Mercury concentration
The average of mercury concentration in seventeen samples	1544.4 µg/L
A highest mercury concentration	7025 µg/L
(WHO) Level	10 µg/L
Reference sample	29 µg/L



Figure(4.7) : Total mercury µg/l in blood samples and reference sample

Table (4.8): Distribution of study group according to age

Age	Frequency	Percent%
19-35	11	64.7
36-50	6	35.3
Over 50	0	0
Total	17	100.0

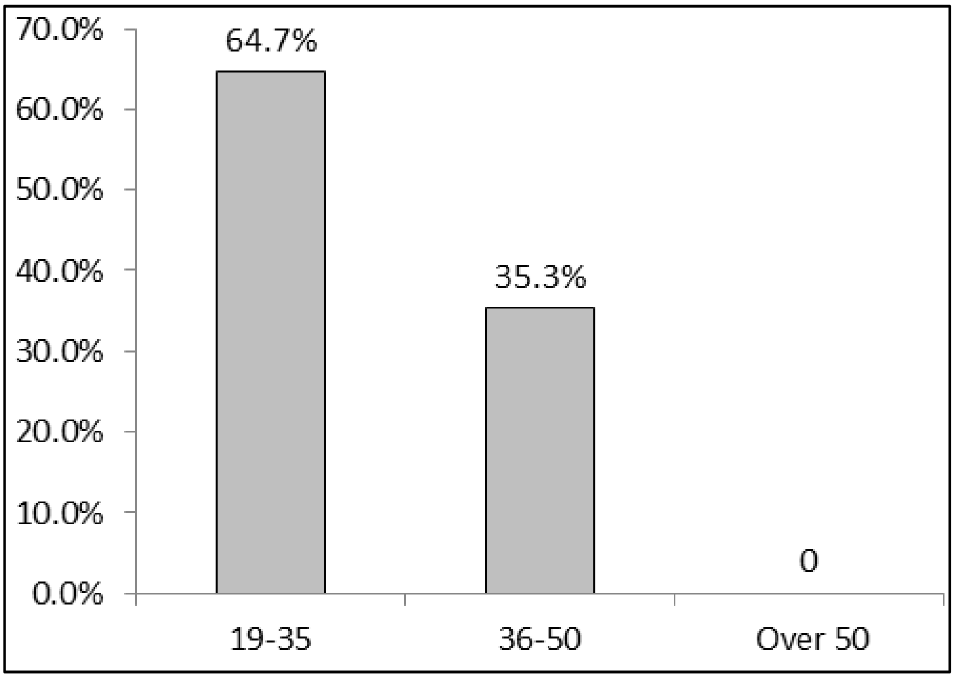


Figure (4.8): Distribution of study group according to age

Table (4.9): Distribution of study group according to marital status:

Marital Status	Frequency	Percent%
Married	11	64.7
Single	6	35.3
Total	17	100.0

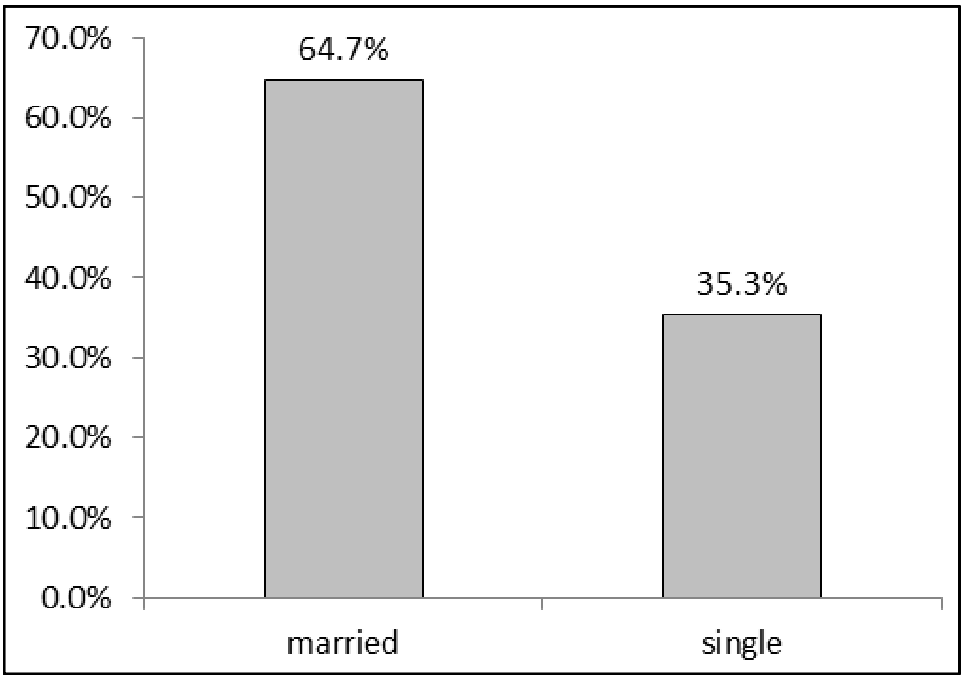


Figure (4.9): Distribution of study group according to marital status

Table (4.10): Distribution of study group according to activity

Type of activity	Frequency	Percent%
Mills	4	23.5
Washing	4	23.5
Mercury Burn	4	23.5
Shops	5	29.4
Total	17	100.0

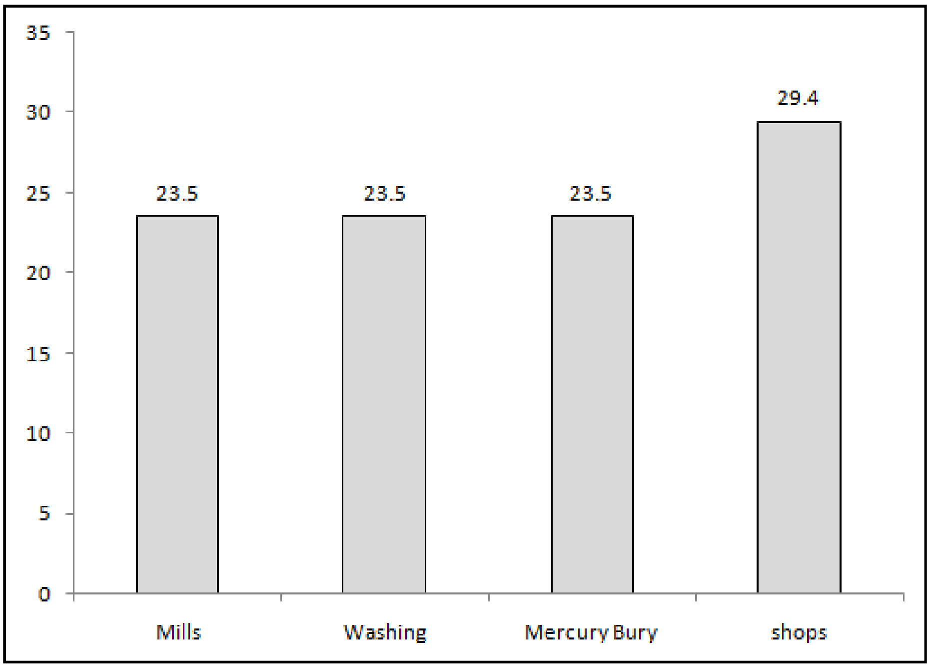
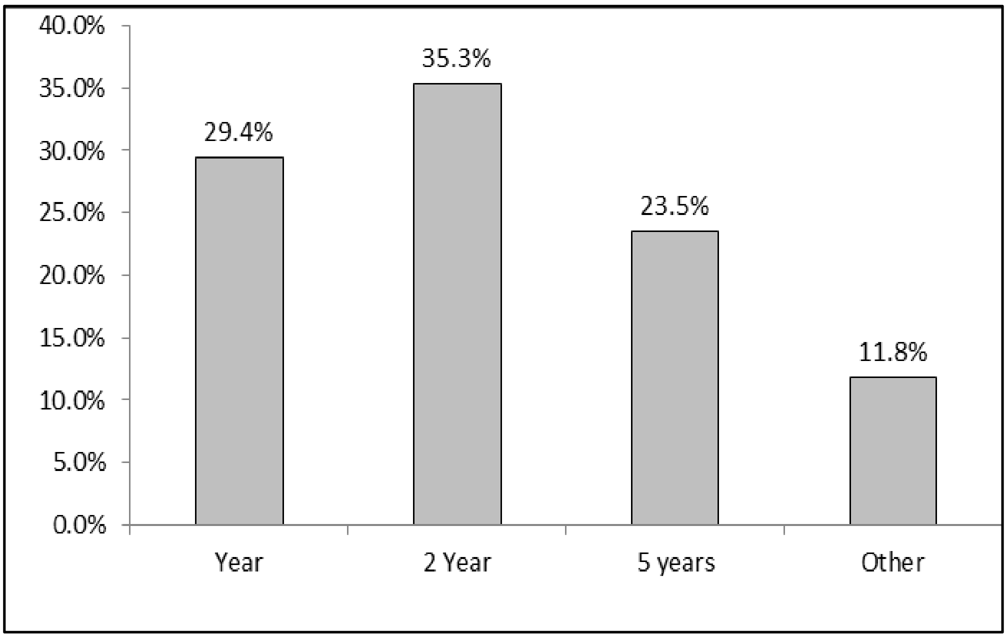


Figure (4.10): Distribution of study group according to activity

Table(4.11): Distribution of study group according to the time period for mining work

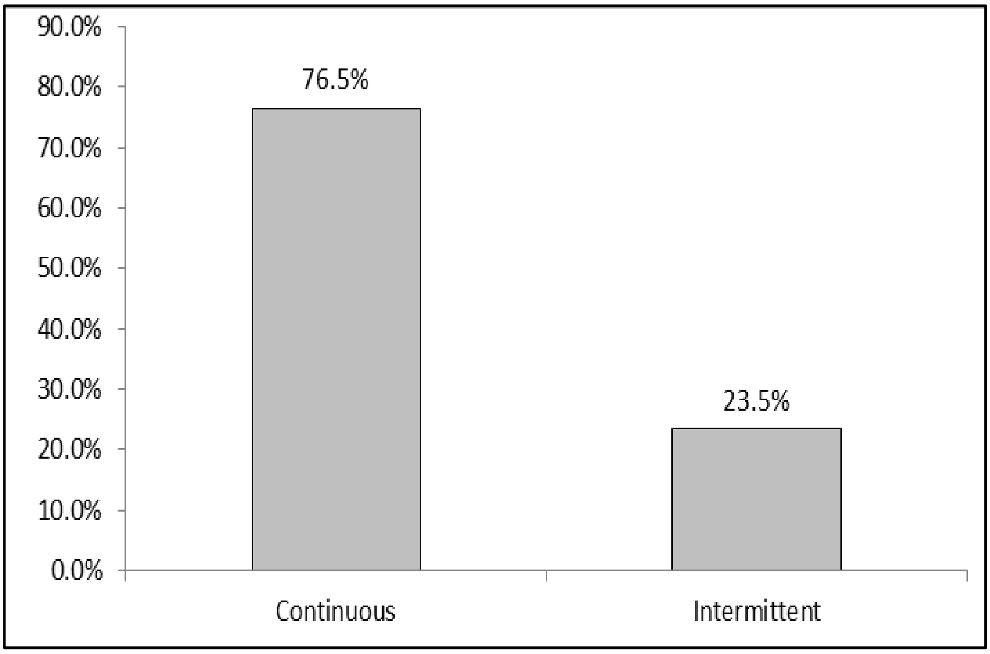
time period for mining work	Frequency	Percent%
One Year	5	29.4
Two Years	6	35.3
Five years	4	23.5
More than Five year	2	11.8
Total	17	100.0



Figure(4.11): Distribution of study group according to the time period for mining work.

Table(4.12): Distribution of study group according to the period of time to work

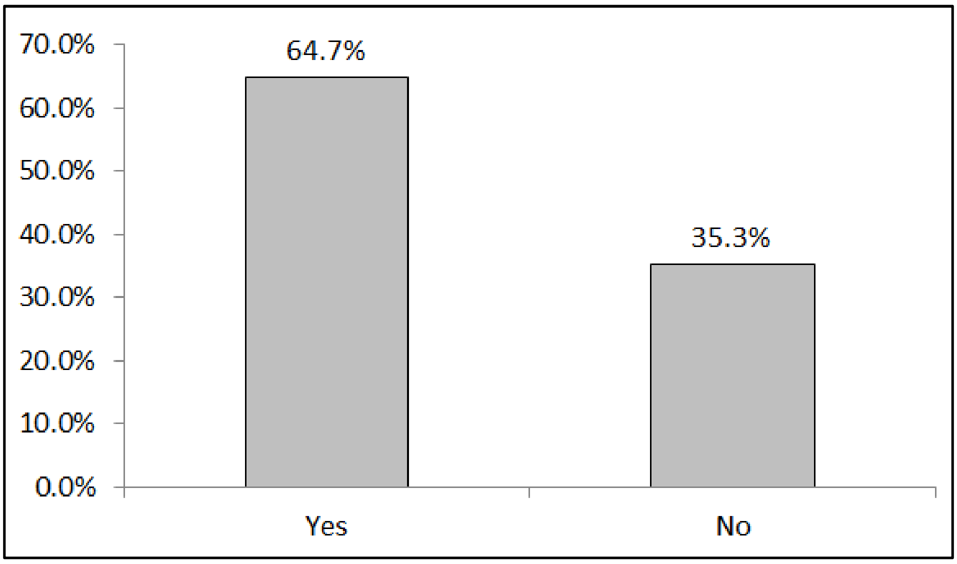
period of time to work	Frequency	Percent%
Continuous	13	76.5
Intermittent	4	23.5
Total	17	100.0



Figure(4.12): Distribution of study group according to the period of time to work

Table(4.13): Distribution of study group according to mercury contact

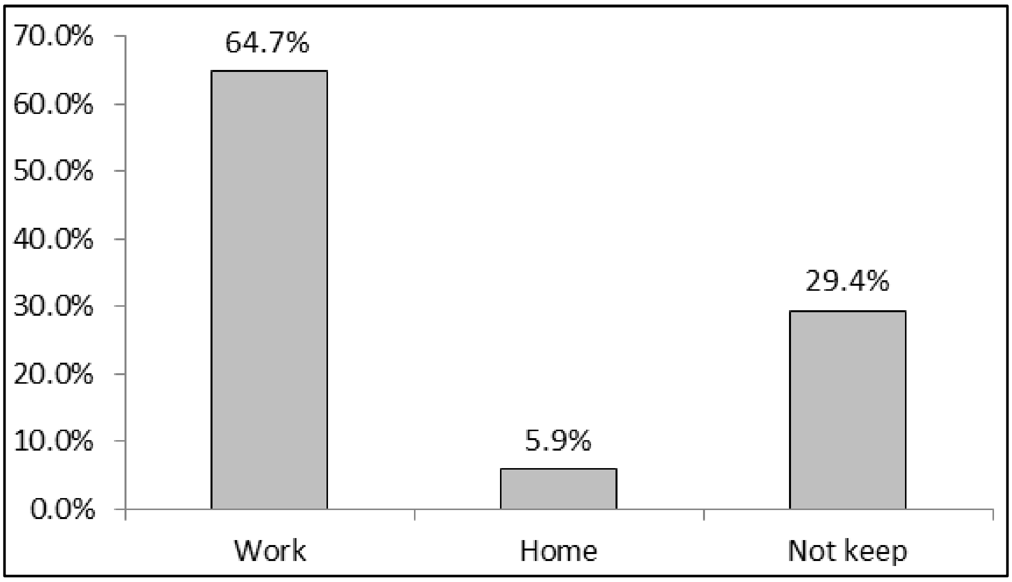
mercury contact	Frequency	Percent%
Yes	11	64.7
No	6	35.3
Total	17	100.0



Figure(4.13): Distribution of study group according to mercury contact

Table(4.14): Distribution of study group according to mercury store

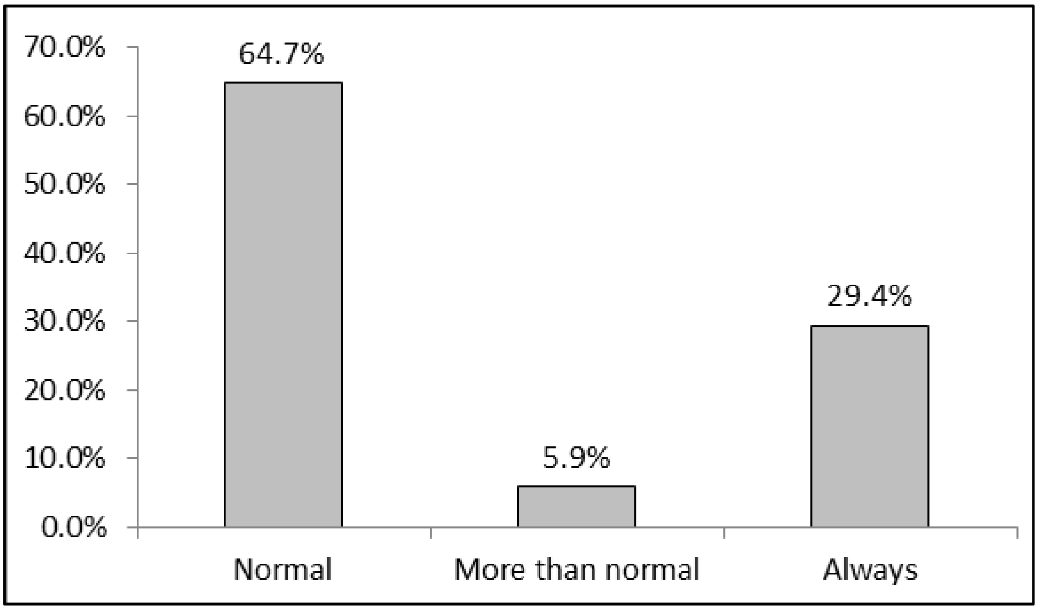
Mercury store	Frequency	Percent%
Work	11	64.7
Home	1	5.9
Not keep	5	29.4
Total	17	100.0



Figure(4.14): Distribution of study group according to mercury store

Table(3.15): Distribution of study group according to feeling weakness

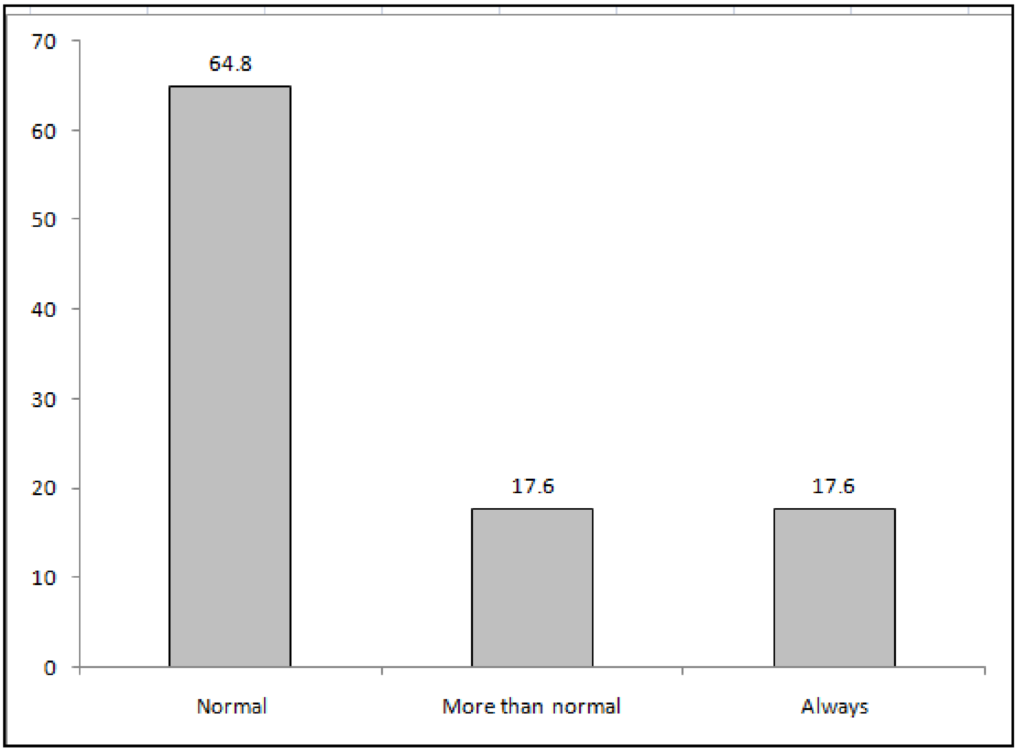
Feeling weakness	Frequency	Percent%
Normal	7	41.2
More than normal	4	23.5
Always	6	35.3
Total	17	100.0



Figure(4.15): Distribution of study group according to feeling weakness

Table(4.16): Distribution of study group according to feeling sleepy or drowsy

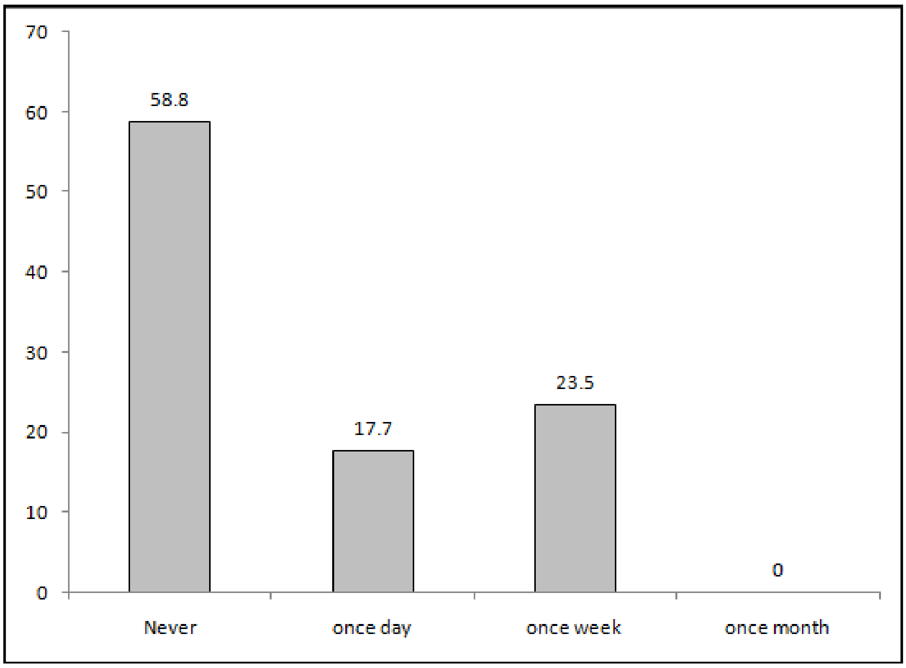
Feeling sleepy or drowsy	Frequency	Percent%
Normal	11	64.8
More than normal	3	17.6
Always	3	17.6
Total	17	100.0



Figure(4.16):Distribution of study group according to feeling sleepy or drowsy

Table(4.17): Distribution of study group according to palpitations

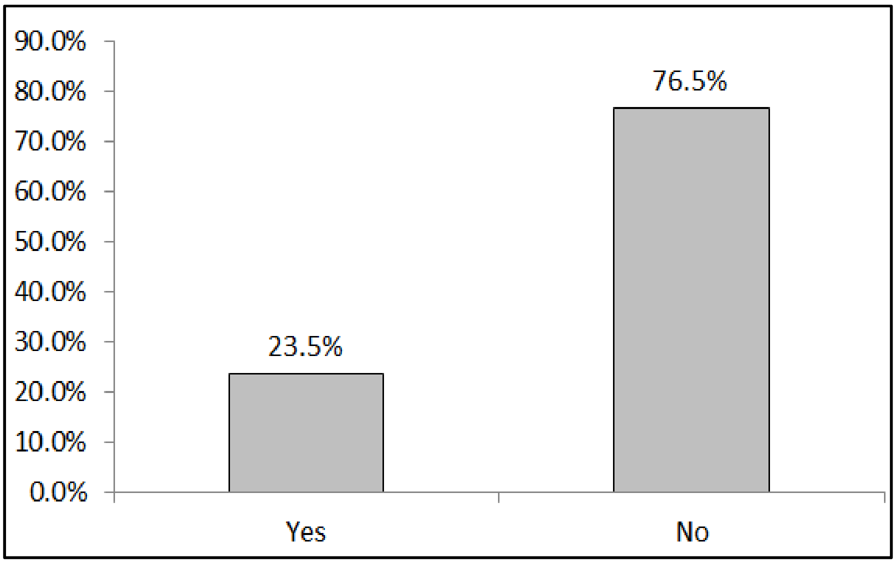
Heart palpitations	Frequency	Percent%
Never	10	58.8
once a day	3	17.7
once a week	4	23.5
Once a month	0	0
Total	17	100.0



Figure(4.17): Distribution of study group according to palpitations

Table(4.18): Distribution of study group according to syncope attack

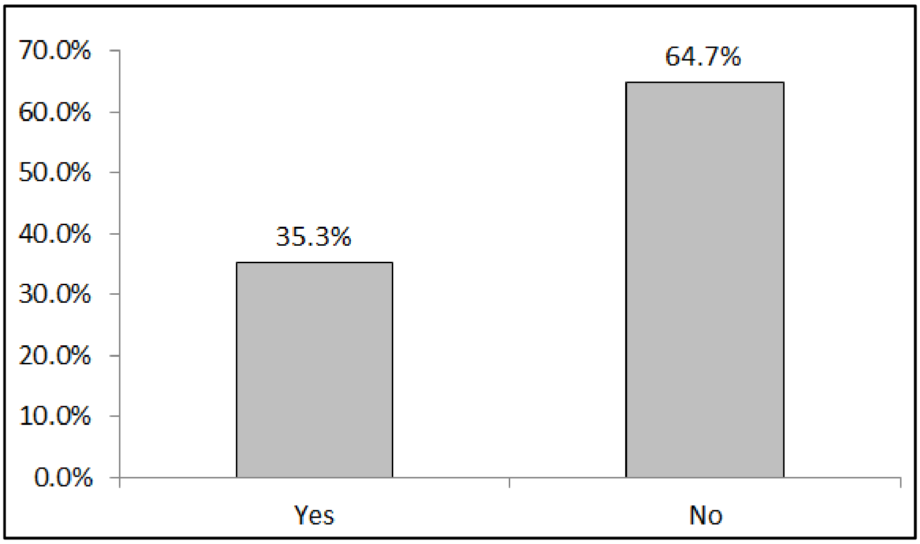
Have you syncope attack?	Frequency	Percent%
Yes	4	23.5
No	13	76.5
Total	17	100.0



Figure(4.18): Distribution of study group according to syncope attack

Table(4.19): Distribution of study group according to achronic disease

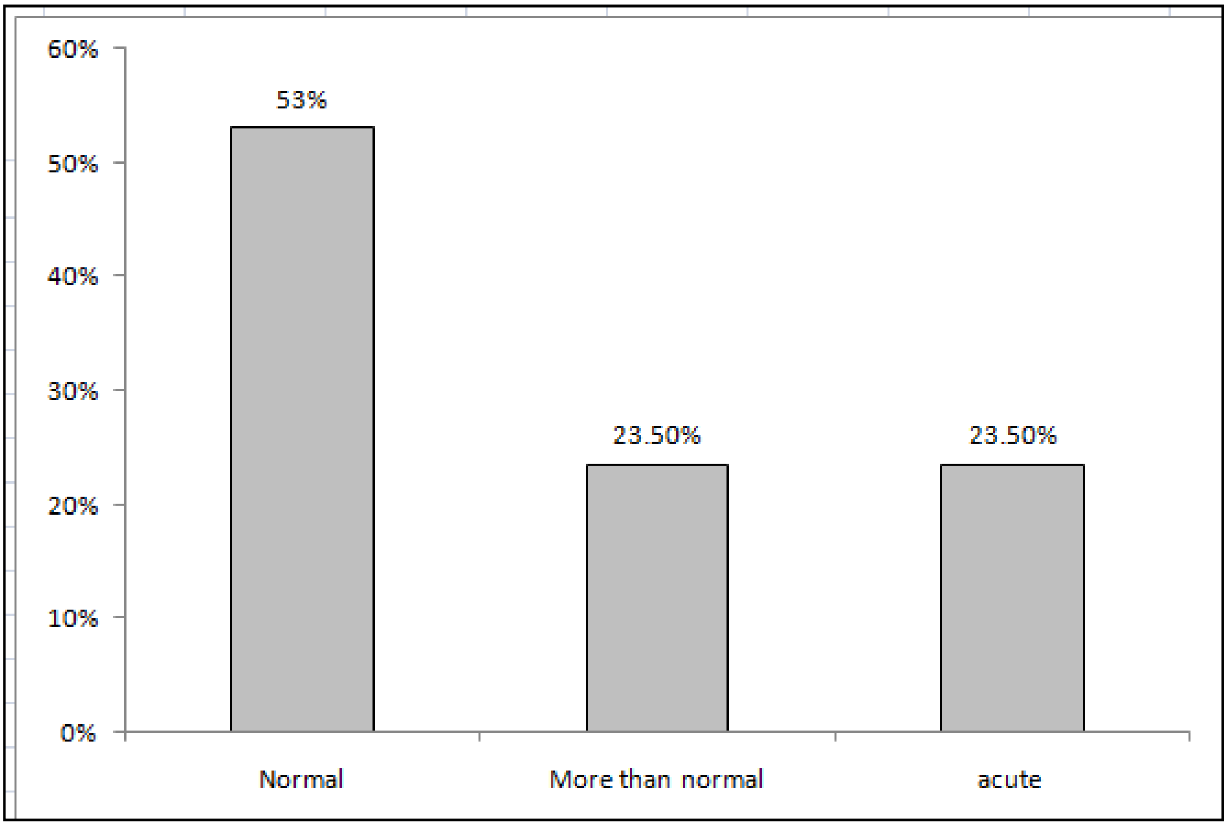
A chronic disease	Frequency	Percent%
Yes	6	35.3
No	11	64.7
Total	17	100.0



Figure(4.19): Distribution of study group according to A chronic disease

Table(4.20): Distribution of study group according to have headache

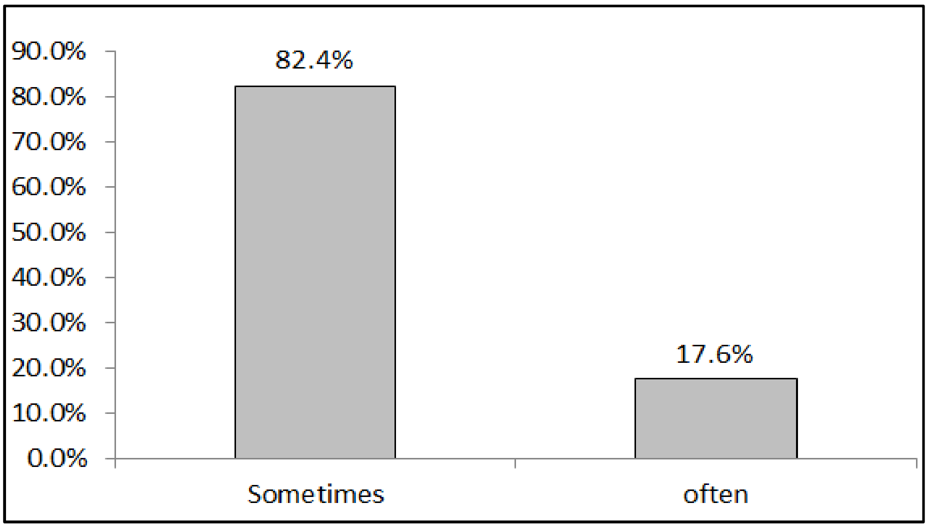
Feeling headache	Frequency	Percent%
Normal	9	53.0
More than normal	4	18.5
Acute	4	18.5
Total	17	100.0



Figure(4.20): Distribution of study group according to feeling headache

Table(4.21): Distribution of study group according to feeling stress and sadness

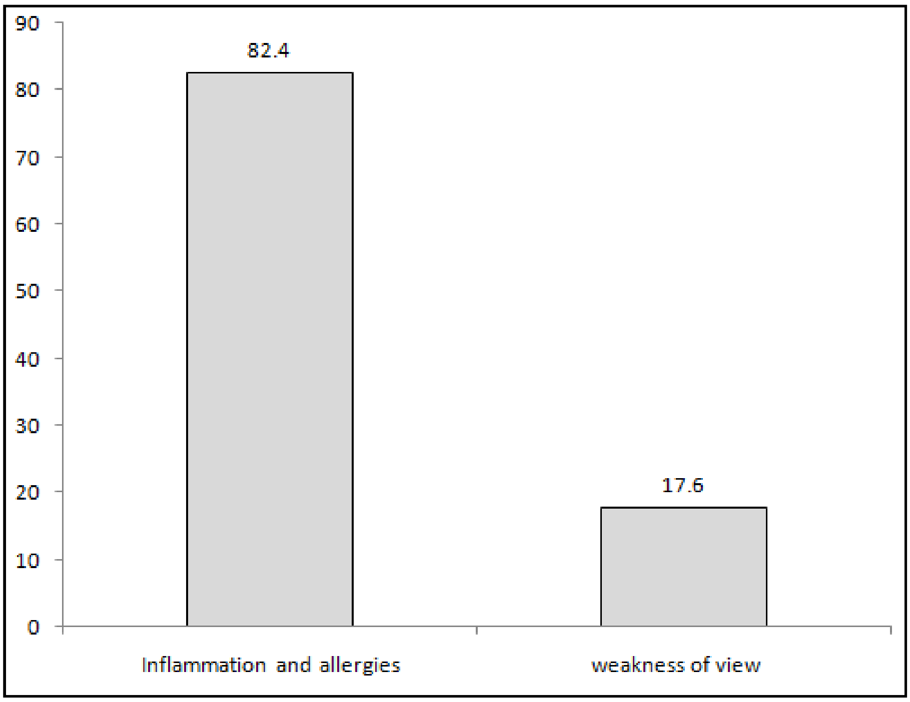
Feeling stress and sadness	Frequency	Percent%
Sometimes	14	82.4
Often	3	17.6
Total	17	100.0



Figure(4.21): Distribution of study group according to feeling stress and sadness

Table(4.22): Distribution of study group according to Eye problems

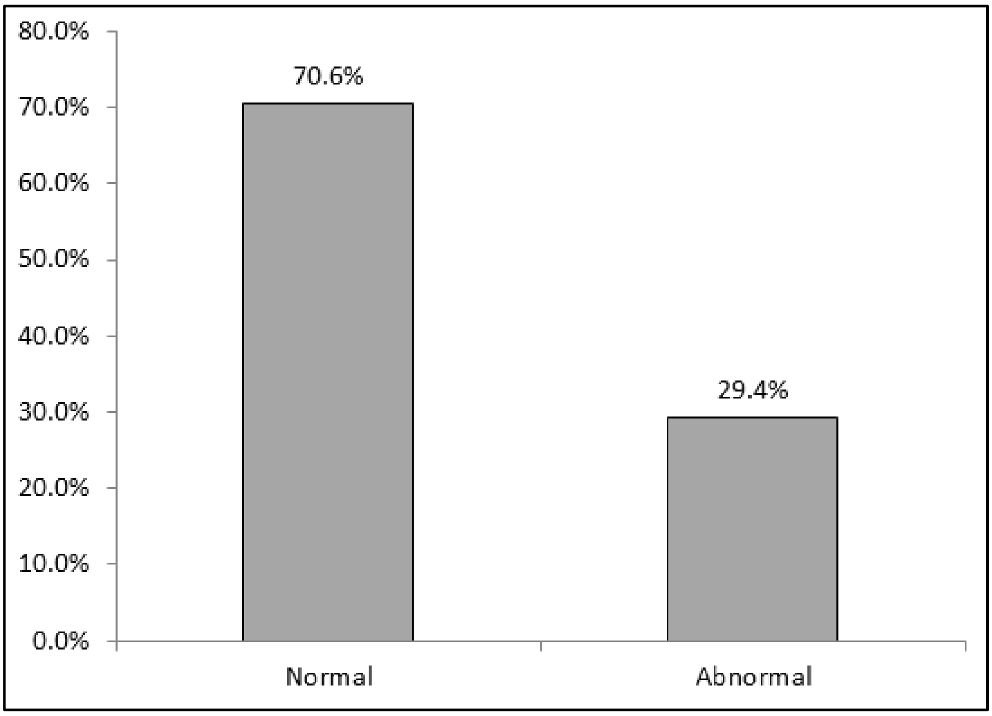
Eye problems	Frequency	Percent%
Inflammation and allergies	14	82.4
weakness of view	3	17.6
Total	17	100.0



Figure(4.22): Distribution of study group according to Eye problems

Table(4.23):Distribution of study group according to Memory problems

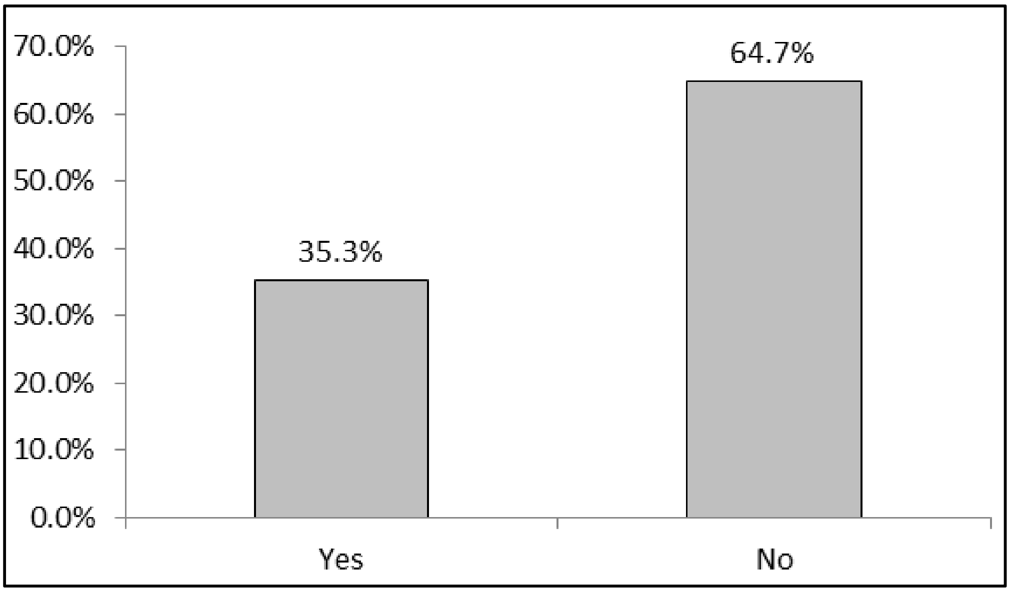
Memory and forgetting problems	Frequency	Percent %
Normal	12	70.6
Abnormal	5	29.4
Total	17	100.0



Figure(4.23):Distribution of study group according to Memory problems

Table(4.24):Distribution of study group according to do you get toxicity during work

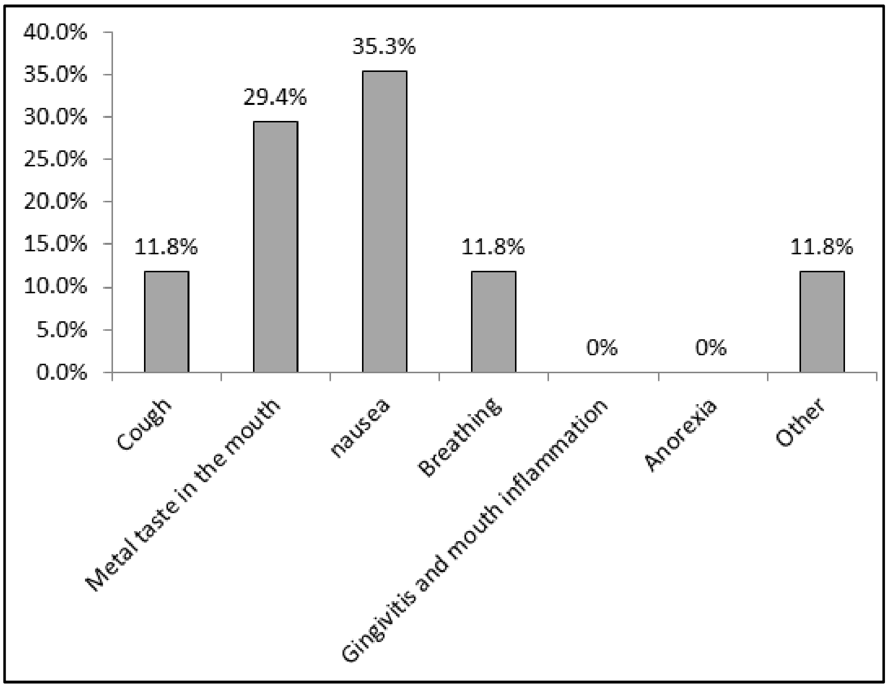
toxicity during work	**Frequency**	**Percent%**
Yes	6	35.3
No	11	64.7
Total	17	100.0



Figure(4.24):Distribution of study group according to do you toxicity during work .

Table(4.25):Distribution of study group according to General health status

General health status	Frequency	Percent%
Cough	2	11.8
Metal taste in the mouth	5	29.4
Nausea	6	35.3
Breathing	2	11.8
Gingivitis and mouth inflammation	0	0
Anorexia	0	0
Other	2	11.8
Total	17	100.0



Figure(4.25):Distribution of study group according to General health status

4.2 Discussion

A serum mercury concentration is one of mercury exposure biomarkers, Mercury is an element that cannot be destroyed, therefore Mercury already in use can be recycled for other essential uses, with no further need for mercury mining, Mercury use in artisanal and small-scale gold, Exposure to mercury vapor in gold mining is an occupational hazard and has been reported in several publications in different areas of the world . Human absorption of liquid Hg is minimal, and acute toxicity does not occur easily, but the problem arises when liquid mercury is heated and bursts into the gaseous phase, which causes acute interstitial pneumonia when inhaled at a high concentration. In the present study the traditional gold miners, work in a hot climate in a deserting area. As seen in the field they treat the mercury as if, a non-toxic substance, especially in washing stage to extract gold from washed stoned powder, and when heating the gold-mercury mixture to evaporate mercury and remain gold in metallic pans. The second source of exposure is that all the serious stages occur in the same area not exceeding few meters between stone milling, washing and molding. The third factor is low occupational awareness among the traditional gold miners. These reasons accumulated together, to find that the serum mercury among these miners are exposed to dangerously high levels . The study show that the average of mercury concentration in blood samples was 1544.4 μg/L which indicated a high toxicity level, Similar finding was also reported in Abo hamad in 2014 gold miners was (24.9 ± 32.24μg/l) versus (1.40 ± 0.94μg/l) in the control group, another study in Iran was reported 208.14 μg/L and the average geometric mean of total Hg concentrations in the blood of was (10.05 μg/L) in colomiba.

A high average concentration of total mercury was 7025 µg/L in burning worker, because directly exposure of to mercury vapor .while an average concentrations in washing, shops workers and mills were 3675 µg/L, 1685 µg/L, and 797.5 µg/L respectively since the control samle concentration was 29µg/L. Table&Figure(4.6) and all high concentrations were found in burning workers and mercury washing respectively who work for longer time .

The study showed 65% of workers age were 19-35 years ,and 64% had directly contact with mercury.

The study showed high incidents of neurological symptoms ,headache feeling stress , feeling weakness and eye problems.

4.3 Conclusions:

The aim of this study was assessment mercury level in blood serum in small gold mining activity at Alabeedya city in River Nile State, sudan. The study showed that the average of mercury concentration in seventeen blood samples was 1544.4 µg/L which indicated a high toxicity level. The study showed the highest mercury concentration 7025 µg/L , the reference sample non miner 29 µg/L and World Health Organization (WHO) the mercury concentration level 10 µg/L but the value of 20 µg/L or below is considered normal, The blood mercury concentration can rise to 35 µg/L after long-term exposure to mercury vapor . Also, the study show high incidents of neurological symptoms headache feeling stress , feeling weakness and problem with eye proplems.

4.4 Recommendation:

- Interventional study should be done using chelating therapy.
- Renal toxicity should be evaluated in people living in gold mining areas.
- Gold miners should use safety tolls (gloves, mask, etc.).
- Monitoring the environment and organic mercury in water.
- Working time in the mining area should be adjusted.
- Studies in city should be conducted to evaluate the community exposure to mercury including pregnant women and children at school age .
- Toxicological study should be conducted to measure mercury in Nile river fish.
- Alternative technologies should be implemented to reduce mercury emission.
- National regional and global actions, both immediate and long-term, are needed to reduce or eliminate releases of mercury and its compounds to the environment. WHO is committed to work with the health sector and national, regional and global health partners to: reduce mercury exposure, eliminate the use of mercury wherever possible. and promote the development of alternatives to the use of mercury.

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بسم الله الرحمن الرحيم

Nile Valley University

Collage of Graduate Studies

Questionnaire about Assessment of Mercury levels in Blood Among Traditional Gold Mining workers in Alabeeya Area , River Nile state , Sudan from October 2019 to March 2020

1 - Age

Less than 18 ☐

19 -35 ☐

36 -50 ☐

More than 50 ☐

2- Marital Status

Single ☐

Married ☐

3- Job description

Mills ☐

Mercury washing ☐

Mercury burning ☐

Workers in shops ☐

4- Time Period of work

1year ☐

2 year ☐

5year ☐

More than 5 years ☐

5- Period of work

Continuous ☐

Intermittent ☐

6- History of Working as Miner With Mercury Contact

No ☐

Yes ☐

7- Where they Stored Mercury container

Home ☐

work ☐

Never store mercury ☐

8- Feeling Weakness

Same As Usual ☐

Worse Than Usual ☐

Much Worse Than Usual ☐

9- Feel Sleepy or Drowsy

Same As Usual ☐

More Than Usual ☐

Much Worse Than Usual ☐

10- Palpitation

Never ☐

At Least Once A Day ☐

At Least Once A Week ☐

At Least Once A Month ☐

11- Syncopal attack

Yes ☐

No ☐

12 - Chronic Disease

No ☐

Yes ☐

If yes mention it

……

Neurological symptoms

13-Headache

Same As Usual ☐

More Than Usual ☐

Much Worse Than Usual ☐

14-feeling stress and sadness

Sometimes ☐

Often ☐

15 - Eye proplems

Conjunctivitis ☐

weakness of view ☐

16- memory proplems

normal ☐

abnormal ☐

17 - Do you have any toxicity during work

Yes ☐

No ☐

If yes mention it …………

18- General health condition

Cough ☐

Metal taste in mouth ☐

Respiratory problems ☐

Nausea ☐

Gingivitis ☐

Loss of appetite ☐

Others ………..