Sources and Effect of Mercury on Human Health:A Review

A project submitted by

Kasfia Tasnim Humaira

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Dedicated to my beloved family and respected teachers who supported and guided me through thick and thin and assisted me to achieve my goals.

Certificate Statement

This is to certify that the project titled “A Review on Mercury Poisoning, Its Sources and Hazards on Human Health” is submitted for the partial fulfillment of the requirement for degree of Bachelor of Pharmacy from Department of Pharmacy, BRAC University comprises of my own work under the supervision of Dr. Sharmind Neelotpol,Assistant Professor of Department of Pharmacy, BRAC University and appropriate credit is given when I have used the language, ideas and writing of another.

Signed

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Countersigned by the supervisor

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Abstract

Mercury is one of the common environmental toxicants that prevails on Earth naturally due to soil erosion and volcanic eruption. This environmental pollutant is also released due to different human activities, e.g., burning coals in power stations, Zinc-smelting, mining of artisanal scale gold etc. There are different forms of mercury such as, elemental, organic, inorganic etc. and they have multiple effects on human health upon consumption or administration. There are different sources of mercury, for example, fish (e.g., shellfish, swordfish), soil, etc. The fish bio-accumulates the mercury by feeding on smaller fishes and planktons. The mercury presence in soil is due to the different anthropogenic activities and later this mercury gets incorporated into the rice, grown in that soil. Mercury is also found in thermometers, barometers, sphygmomanometers as well as electric devices, such as, electric switches, relay equipment, lamps etc. Occupationally, people in dental clinics, choir alkali plants and mercury nines and industries of pesticides and insecticides are exposed to mercury. The major sources of occupational mercury are China, Spain, Kyrgyzstan, Algeria, Russia, Slovakia etc. The element is non-toxic upon direct consumption but is poisonous if its vapor or agitated form is inhaled. It is harmful to the lungs, liver, kidneys as well as the nervous system. It is highly detrimental for both central and peripheral nervous system of children. Fetuses are exposed to mercury through placental blood and nursing infants consume mercury through mother's milk and hence they suffer from major drawbacks too. Upon inhalation of mercury vapor, it may cause bronchitis or pneumonitis as it has certain necrotizing effects. Occupationally, dentists or choir alkali workers may suffer from neurological, nephrological, immunological, cardiac, reproductive, motor and genetic disorders. The review summarizes the physico-chemical properties of mercury. It highlights the different visual and hidden sources of mercury available in our surroundings. It clearly describes the pharmacokinetic and pharmacodynamics effects of mercury. It also mentions how mercury poses threat to human health and population of different age-group. Finally, there is a comparative study between Bangladesh and other countries where merecury poisoning is most available due to the significant sources being present prominently.

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CHAPTER:1

INTRODUCTION

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1. Introduction

Mercury is a naturally occurring element that exists in its atomic or ionic state (Hg/Hg^{2+}) and it is found in many other organic and inorganic forms (Qui, *etal*. 2012). It is a severe environmental toxicant, threatening life worldwide (Feng and Qui, 2008). The pollutant prevails on the Earth's crust naturally because of the environmental changes, for instance, soil erosion and volcanic eruption and also due to the human activities, for example, substantial contamination of environment with mercury.

Since past twenty years, China is the major source of increase in mercury due to increase in anthropogenic activities. Simultaneously, the world economy was flourishing and population explosion occurred. Records have been published on distribution, transportation, bioaccumulation and methylation of mercury (Qui, *etal.* 2012). There are ultimate ways to get exposure to mercury through human activities, e.g., zinc smelting and industrial activities (Tichoumeu, *etal.* 2003, Feng and Qui, 2008).The excessively increasing Chinese population experiences the ambient mercury level rising. The geologic areas are extremely populated with mercury coming from coal-lined power-plants etc. Some of them are suited for crop cultivation, as well as, soil, water and air are contaminated (Qui, *etal*.,2012). The process goes cyclically. Some of the anthropogenic sources of mercury emit mercury by 6.3%-10.3% in Gouizhou, China. The same Hg-rich soil emits the ambient atmospheric mercury in the air (Feng and Qui, 2008).

Other means of getting exposure to mercury are from occupational sources Coal mines are present in Spain, Kyrgyzstan, Algeria, Russia, Slovakia, (Manamb, *etal*. 2008). Abandonedmines are getting alarming day by day due to long term environmental pollution in Gouizhou, China.Mercury contaminated soil are said to contain low doses of mercury if they contains 5mg/L and high doses of mercury if the concentration of mercury is 1600mg/L in the soil, Fishes in the river along with other aquatic life are being affected. (Qui, *etal.*2012). Details of prolonged exposure to organic mercury are mentioned below. One of the organic forms of mercury, methylmercury bio-magnifies as it gets accumulated

in the large predatory fishes upon consumption of the planktons. As human being feed on these fish and shellfish, mercury becomes gradually concentrated in the blood. Similar effects occur due to inhalation of elemental mercury or mercury vapor during industrial processes.

Complete accumulation of total mercury and methylmercury is also found in the rice, in equal proportion that are grown in polluted and non-polluted areas (Rutherberg, *etal.*, 2015). The polluted areas include artisanal small-scale gold mining, zinc-smelting and lead mining plants, proximity to coal power-plants, e-water etc. and the non-polluted area being contaminated with mercury are paddy fields for irrigation. Other sources of mercury are batteries and measuring devices, such as, thermometers and barometers, electric switches and relay equipment's as well as lamps are potential sources of mercury (Aleveki, *etal*. 2012). Some other products include dental amalgam, skin-lightening products and pharmaceuticals too. Some of the occupational sources of mercury are choir alkali plants. Mercury mines, refineries and dental clinics along with mining and manufacturing industries of gold and mercury. Other materials include skin lightening creams (Park and Zheng, 2012, Berrdoft, 2011), traditional medicines (Park and Zheng, 2012). Mercury is also an established pollutant in the air(Qui*etal.* 2011, Alevedu, 2011). The most noticeable sources of mercury are dental amalgam (Park and Zheng, 2012, Tichoumeou, *et al*. 2003), cosmetics (Park and Zheng, 2012, Tichoumeou, *et al.* 2003) and toxic foods, particularly fishes, for instance, tuna fish, swordfish and shellfish (Tichoumeou, *et al*. 2003). It is found from the base of the ocean by degassing process, to be taken out to the Earth's crust.The various forms of mercury are methyl, ethyl and phenyl forms of mercury forms are found in the industrial products, for example, biocides, pesticides and insecticides, Phenyl mercury is also constituent in fungicides, in diaper rinsing solution, and latex paint, It also leads to conditions acrodynia leading to miserable conditions in babies (Tichoumeou, *et.al*. 2003),

The pure elemental state of mercury is liquid when it is called "quecksilver". Mercury is not toxic upon direct consumption as it cannot penetrate the gastrointestinal tract and is excreted in the urine and feaces (Park and Zheng,2012). However, the heated and agitated form of mercury causes direct poisoning to the lungs, nervous system. The majorly vulnerable site for mercurytoxicity is nervous system as well as liver, kidney and lungs

(Berroft, 2012) . It is considered to be very hazardous for peripheral and central nervous system of children. It also causes arrhythmias, cardiomyopathies and kidney damages. Upon inhalation of mercury vapor,it has necrotizing effects causing bronchitis and pneumonitis that may lead to respiratory failure. Mercury is also considered an immune-stimulant and immune-suppressant on the basis of exposure level of the victim to its vapor. As a result, the person may suffer from lymphoproliferation, hypergammaglobulinemia and total system hyper and hypoactivities. (Tichoumeou, *et al*. 2003).

People of different age-group are being affected by mercury-poisoning. Fetus are more susceptible to mercury-poisoning in their cellular and sub-cellular functions is being hampered((Bedroft, 2012).Mothers consuming diets rich in mercury pass on the toxicants to the fetus through placental barrier and infants through breast milk (Rizw, *etal*. 2005). Pneumonitis may occur due to exposure to large amounts of mercury vapor(Berrdoft, 2012). For people having profession of a dentist, a choir-alkali worker, a gold-mining worker, mercury is responsible forvariant types of disorders, e.g., neurological, nephrological, immunological, cardiac, motor, reproductive and genetic (Riwz, *et al.*2005). According to recent information , heavy metal toxicity have relation with diseases , like, Alzheimer's, Parkinson's, autism, amyotrophic lateral sclerosis (Riwz, *et al.* 2005). The mercury fatalities are at their extreme levels due to the net mercury intoxication involves neurotoxicity during the prenatal and postnatal periods, including many other pronounced effects. The ultimate consequences are mental retardation, cerebral palsy, seizures leading to death (Tichounwou, *etal*. 2003).

Therefore, the overarching aim of thisstudy is to find out adverse effects of Mercury on human health from life by reviewing different sources of mercury in our everyday life from various peer reviewed journals.

The research questions addressed in this study are:

- What are the properties of mercury?
- What are the visual and hidden sources of mercury?
- How does mercury poisoning cause health hazards to humans?
- What are the scenario of mercury poisoning in Bangladesh and worldwide?

CHAPTER:2

METHODOLOGY

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2. Methodology:

This review paper is a summary of the recent condition of mercury poisoning. The articles have been collected from the NCBI Resources, Hindawi Publishing Corporations (Journal of Toxicology), Journal of Environment and Public Health, Springer-link, BioMed Centre, Elsevier, World Health Organization, Journal of Biomedicine and Biotechnology, British Medical Bulletin, Journal Law and Health. The review paper discusses on the different sources of mercury exposure which are natural, terrestrial, aquatic. Others are human related sources of exposure which include inorganic and organic mercury. The mercury toxicity can also be categorized on the basis of the different sites and locations where mercury is more available or being used more often.

CHAPTER:3

LITERATURE REVIEW

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Literature Review:

3.1 History of Mercury

The Earth contains a fixed amount of mercury.The cycles of mercury continues from deep earth, to the atmosphere to terrestrial reservoirs and water-bodies on timescales that varies from less than one year to a thousand. Excluding the toxic effects of mercury, it has many chemical properties that make it very useful to humans. It has been evidenced that mercury has been used ubiquitously throughout the human skeleton in 5000BC as verimilion, or cinnabar (HgS). At 15th century, the use of mercury in Egyptian ceremonial cup is another example of its utility.

From the Roman times, human have been mining mercury ores from the deep earth, “lithosphere”. Prisoner and slave labors were used to operate a mercury mine in Spain under Roman Empire. Mercury was used as paints during those times. In 7BC, the houses with mercury-paints were found buried under the volcanic ashes of Mount Vesuvius. The use of mercury in paint has been found into the modern area. In recent history, mercury was added as a fungicide, althoughit has chromatic properties. In US, mercury was used upto 1991 in paints after which the use of mercury in paints has been phased out in order to avoid its harmful effectto the health.

In the oldest known written record of mercury of Aristotle back in 4^{th} century, mercury has been referred as “fluid silver” and “quicksilver.” The message of the academic text was that alchemists of his day believed that mercury was the component in all metals that gave them their “metal-ness. People of that time used it in ceremonies and as an element for ailment for skin disorders. Since 500BC, Indians and Chinese used it as an aphrodisiac and for medical therapy. Mercury was medicine for contraception among Chinese woman 4,000 years ago. One of the popular traditional sedative medicines is cinnabar which is actually HgS.

Mercury was used to extract gold by amalgamation by the year 1000CE. The workers then burn the pellets of gold that are surrounded by mercury. The mercury evaporates as purified gold. The artisanal small-scale gold mining operations still practice this today. Over 10

million of workers are exposed to the toxic element and between 650-1000 tons of mercury is being released per year into the environment.

After 1943, the barometers were invented and after 1720, the mercury thermometers came in use. Onwards, mercury was in use immensely. Today, mercury thermometers are no more being used in health-care sector though Chinese still use some sphygmomanometer containing mercury.

In 1798, various inventions increased the demand for mercury. During the Industrial Revolotion, explosives were detonated with the help of mercury compounds, for example, mercury fulminate. In 1835, first industrial production of polyvinyl chloride (PVC) took place under the catalysis of mercury.. In 1891, mercury was present in Thomas Edison's incandescent lamp whereas mercury is added to compact fluorescent light bulbs these days. In 1894, H.Y. Castner discovered that mercury could be used in the choir-alkali process to produce chlorine and caustic soda. And during World War II, the Ruben-Mallory battery (mercury dry-cell battery) was invented and widely used.

In the beginning of 1900s, the commonest applications of mercury were producing scientific apparatus, retrieving gold and silver from their mines, synthesizing fulminate and vermilion in large scale and in manufacturing felt. It was noticed that workers in felt-industry suffered from dementia which is a symptom of mercury poisoning.

By the 1960s, 90% of the mercury production included electrical apparatus, caustic soda and chlorine. Caustic soda is mainly related with the paper-manufacturing industry; it is useful for preparation whiter paper. Excluding Chinese manufacturers choir-alkali manufacturing has now switched to non-mercury method.Still, 1% of total mercury exposure into the environment takes place through the choir-alkali plants,which isa strong source of mercury exposure to water and land.

Until 1850, the global supply of useful mercury was obtained by extraction from three mines located in Almaden, during Roman era); Idria, Slovenia; and Santa Barbara, Peru (which the Spanish ruled over during colonial times). Between 1850 and the 1960's, the Santa Barbara mine was closed manufacturing and mercury mining initiated in two other regions: in Monte Amiata, Italy, and throughout California in the United States. The latter coincided with the

Gold Rush. From 1960, other mines have begun their extraction work in the Soviet bloc countries, China, Kazakhstan, Algeria, Mexico, and the US state of Nevada. In spite of evolution of new mines in recent years a report from the EU infers that recycling of mercury from products and by-products could assist fulfil the demand for mercury as well as cut down the need for mercury extraction from mines directly.

Reflecting upon various uses of mercury in past shows its uses in various utilities in modern products and processes. According to an estimation, more than 4000 years ago, the historical and current emission of mercury from its different application released over 350,000 tons of mercury from the depths of the earth into air, surface land, and water.Thereby, the health of human beings and other creatures on earth are at risk.

Mercury is one of the toxic elements present in nature that is also responsible for environmental pollution .It has vast uses starting from industry to agriculture and medicine. It prevails in the ecosystemwithout being ruined.As a chemical, mercury has different forms as elemental as (metallic, Hg^{2+}), mercury: inorganic mercuric compounds and organic mercuric compounds.At room temperature, elemental mercury is found in its liquid state.Due to high vapor pressure, release of elemental mercury can easily take place into the environment. There are two oxidative states of inorganic mercury which are mercurous (Hg^{2+}) and mercuric salts (Hg^{3+}) .These generally exist in solid states as mercurous and mercuric salts and mercury compounds as, chlorine, sulfur or oxygen. Methylmercury and ethylmercuryare common forms, of mercury combined with carbon.With the help of micro-organisms in the environment, methylation of mercury takes place leading to formation of methylmercury.The exposure to main forms of methylmercury is from the seafood, the inorganic mercury from foods and mercury vapor from dental amalgam.

3.2 Physico-chemical Properties of Mercury

Elemental mercury (Hg) has the following characteristics:valence of 1 or 2, atomic number 80 and atomic weight 200.9. Their melting point is 38.37 ºC and boiling point is 356.8 ºC. It has density of 13.546g/ml at 20ºC. At room temperature, it is liquid. It is not properly absorbed in the gastrointestinal tract. It gives a silvery white shiny appearance.At 20ºC the vapor pressure is high enough to equilibrate to air to reach concentration of 130 times

wherethe maxima industrial allowance is 0.1mg/m^3. Depending on the individual susceptibility and exposure time and concentration of mercury (40-400ml of vaporized liquid) in a room, health problems become apparent. Hence, it is a potent toxic biohazard at room temperatures (Tichoumwou, 2003).

Use of elemental mercury is found in thermometers and sphygmomanometers.It is due to its uniform volumetric expansion, high surface tension, lack of vitreous adherence to surfaces.It is used in electrical and electronic material due to low electrical resistance and high thermal conductivity. For possessing high oxidative power, metallic mercury is used in electrochemical operation in the chlorine and soda industry. Metallic mercury is also used in metal-logy, mining and dentistry due to its easy amalgam-formation with other metals (Azevedo, *et al*., 2012).

3.3Sources of Mercury

The most prominent sources of mercury are discussed below.

3.3.1Fish

Factual information states that mercury is initially present in fishes in trace amounts. It is naturally available in the environment, its flora andfauna. The major contributor of mercers are the anthropogenic activities, like, coal-fired power plants, non-ferrous or zinc-smelting,, land-fills , incineration of waste, chemical plants, artisanal golf-mining, mercury mining and retorting sites, release water contaminated with mercury in nearby rivers, seas or oceans. The mercury present in water is in its inorganic form with is converted to the organic lipophilic compound, methylmercury by the biotransformation or microbial actions of bacteria. There is SO_4^{2-} ions present in the water that is taken up by fishes and excreted by them as S^{2-}. The negatively-charged sulfide combines with the positively-charged mercury to form HgS. The HgS descends upon the sediments from where their biotransformation takes places with the help of bacterial actions(Winner, 2010). Eventually, the methylmercury is being consumed by the phyto-planktons and zooplanktons. As the creatures are being consumed by the fishes, the methylmercury enters into the food chain. Mercury, in its organic form, bio-accumulates in the larges fishes as they feed on the smaller ones. In this way, mercury bio--magnification takes place along the food chain. People who

are used to feeding on fresh-water or marine environment fishes are highly prone to exposure to methylmercury, (Zahir, *et al*. 2005, WHO, 2016). Thereby, it is more risky to feed on larger fishes, e.g., Bluefin tuna, walley, king mackerred, marlin, bluefish, shark, swordfish (FDA, 2004), wild sturgeon, opah, bijeyetuna.In comparison to the previous ones, the following list of fishes are comparatively less harmful: Chilean sea hass, sea-crab, lingeod, Spanish mackered, spotted, scattered searout, wahoo. Goupter, snappere, halibut , tilefish, rock fish, sable fish, bluefin, albacore, yellowfin tuna (Berrdoft, 2011, Malkard, 2015, Barrett, 2010, Sette,*et al*. 2004).

Methylmercury is a ingrained neuro-toxicant at minimallevels of exposure. It bio-accumulates to various concentrations in different fish species. Thereby, it poses severe hazardous effects on n the development and functioning of the human central nervous system, especially during intrauterine life. Most studies on MeHg exposure have focused on high-level consumers from local fish sources, although mercury (Hg) is also found in fresh, frozen, and canned market fish. Furthermore,, less has been known on the temporary changes in blood and hair Hg levels in expecting women. Such observations is found in particular in populations with low levels of Hg Fish consumption from the Great Lakes and the St. Lawrence River .There fish consumption has been decreasing over the last years due to advisories and higher alertness of the availability of different pollutants . For non-occupational population, the prominent dose of methylmercury enters, through feeding on contaminated fish shellfish. Cooking does not eliminate mercury from foods. Along with methylmercury in food, inorganic mercury also gets accumulated in the consumers. (Stephen-Bose O Relly,2011)

Exposure to methylmercury takes place mainly through ingestion. Absorption of the organic mercury takes place very easily along the gastrointestinal tract from food, such as, fish. Following ingestion inorganic mercury gets absorbed through the gastrointestinal tract. However, the level depends on how much soluble the inorganic mercury compounds are.In general, as solubility of inorganic mercury increases, its level of absorption increases too. Some Ayurvedic and traditional medicines contain inorganic mercury salts.Absorption of liquid mercury is poor through the gastrointestinal tract. For will absorption of mercury, it needs to be vaporized at first. The absorption of mercury vapor is negligible as the vapor is

attached to the sulfhydryl groups in the gastrointestinal tract. Therefore, consumption of liquid mercury is comparatively less hazardous to human health than consumption of organic or inorganic mercury. Eating fish is the major pathway of exposure to methylmercury for children in most countries in the European Union, North America, and Japan . According to epidemiologic studies in many countries,consistent suggestions came that fish intake is the single most influential predictor of blood or hair mercury levels. A couple of cases to be considered involve persons with high or particular consumption patterns of fish, and anglers and others who consume wild catch. High-level fish consumers are of particular concern, those who select fish from the higher trophic levels of food webs, such as tuna, bass, mackerel, or swordfish, as these are known to contain higher concentration of methylmercury in edible tissues. A case study of such a scenario was published by Hightower and Moore. 7 children took part in the study who consumed tuna in sushi and sashimi. One of these children, a 7-year-old boy (who also consumed mackerel), showed a hair mercury concentration of 15µg/g after 32 weeks without fish in his diet, his hair mercury level was below 1 µg/g. Fish is a rich in protein and omega-3 fatty acids.It should be part of a healthy diet. These fish ingredients are important for a child's proper development Thereby the useful properties of mercury are more prominent than the delirious effects of mercury.

Fishes, deficient in mercury content, are suitable for consumption of women who may become pregnant, pregnant women, nursing mothers, and young children.. These vulnerable subgroups should not consume shark, swordfish, king mackerel, or tilefish containing high levels of mercury. Women of childbearing years and children are urged to eat local panfish and gamefish parsimoniously, and to circumvent all consumption of muskellunge, a top predator species. They are advised to consume up to 12 oz. (2 average meals) a week of fish/shellfish that are known to have lower mercury concentrations. People often ingest noncommercial procured fish (including fish caught locally by family and friends). In these cases they are advised to check local advisories about the safety of fish caught in local lakes, rivers, and coastal areas. If no advice is available, they can consume up to 6 oz. (1 average meal) per week of fish caught from local waters, but not any other fish during that week (Rice, 2014).

Breast milk contains methylmercury in it as an excreted product for those nursing mothers who consume fish rich in mercury. There is not much knowledge about how inorganic mercury is removed from the body.Studies on animalhave led to the fact that mercury from mercury vapor is removed from the body through milk.

3.3.2Rice:

Along with fish, rice is a major source of organic mercury, methylmercury. Methylmercury is a highly toxic and bio-accumulative organic form. Most other food sources have an average of 20ug.kg of methylmercury exposure. From relevant source it has been found that Orya Sativa L, harvested from abandoned mining area contain >100ug/kg in its edible portion and has been confirmed to be 10-100 times higher than other crop plants. Exposure to methylmercury is really high due to daily consumption of rice. Hence, rice is proven to be a major bio-accumulator plant in comparison to other plants (Qui, *et al*. 2008, Zhang, *et al*. 2010) .

As suggested by dependable sources, 94-96% methylmercury exposure takes place through consumption of rice whereas 89-97% of total mercury exposure occurs through rice, vegetables and meat (Barret, 2010). Methylmercury has been identified as a highly neuro-toxic substance through different disasters. Besides exposure to methylmercury through fish and marine life, there are high chances of exposure through soil of mining areas, e.g., 58 people in Wauchuan getting exposed to methylmercury. A research study has shown increased concentration of methylmercury and total mercury. In rice, the staple food of local people. The concentration of methylmercury in pork meat, vegetables and drinking water is much less than the total mercury level. A relationship has been found in estimated methylmercury intake and hair methylmercury. Therefore, it can be concluded that consumption of fish is not the only source of methylmercury exposure but rice, from mining areas, is also responsible (Feng, *et al*. 2008).

Sampling 155 rice plants from three most common mining regions in China (Huran, Guizhou and Guangdong was done by separating the root, stalk, leaf and seed (brown seed). The highest concentration of methylmercury in roots was found in the soil with majorly contaminated with mercury. The obvious discrepancies between total mercury and

methylmercury reflected different pathways of their accumulation. Water-soluble mercury may also be responsible for the total mercury and methyl mercury(Meng, *et al*. 2014).

In order to reduce the THg and MeHg in the grains, two methods have been devised which are irrigation method and deliberate selection of rice cultivars. Growing rice in aerobic condition cuts down the concentration of THg and MeHg and deduces the proportion of MeHg in grains. There have been remarkable difference found between THg and MeHg.in grains among the 24 cultivars harvested from the same paddy field. Another important variable was the mercury tolerance index, i.e., the control root growth that varied noticeably among cultivars (Cheng, *et al.* 2006).

Another research showed the relative bioaccumulation of the methylmercury and inorganic mercury in the plants. The survey was done, in total, on 59 sites among which 32 sites were "heavily-polluted sites", 19 were "less-impacted sites" and 8 were 'control sites". The inorganic mercury (IHg) and methylmercury (MeHg) were measured. The bioaccumulation factor (BAF) ranged from 0.00014 to 0.71 and 0.71 to 50 for MeHg. It is on average 800 times higher than IHg (Zhang, *et al*. 2010).

It has been evident that tissue of rice grain gathers maximum THg and MeHg than any other parts of the crop. This fact has been proven from the study where *Oryza sativa* (rice) was harvested from different grounds of a mercury contaminated area.The whole plant was divided into rice seeds (brown rice), hull, root, stalk and leaf. Cultivated plants from the Hg smelting and artisanal Hg mining areas, are loaded with large amount of Inorganic mercury and methylmercury. Observation states that the ambient air being contaminated with Hg also contributes to the Hg in rice plants but the plants harvested collected the mercury from the contaminated soil (Meng,*et al*. 2010)

Despite no further use of methylmercury containing fungicides,e, mercury may still be present in rice. According to a research conducted in Saudi Arabia, the concentration of rice was found below the 43 µg/d. The Food and Agriculture Organization/WHO states that this value of intake of mercury in rice only is tolerable. Rice is relatively a prime source of mercury exposure, Along with use of fungicides; mining activities are also liable for mercury exposure into the food chain, particularly in those areas where people feed on rice.

A survey of Wanshan mercury mining area in the Guizhou province of China verified that rice harvested from that land contains ample amount of total mercury and methylated mercury. Most importantly, the population consume rice as their staple food.(Stephen-Bose O-Relly, *et al*. 2011).

3.3.3Soil

Amongst most significant mining zones of the world, the province of Guizhou in Southwestern Chaina is one to be mentioned, Approximately 12% of the total world anthropogenic emission of mercury is contributed by the mercury emission from this province. From an authentic source, it has been found that Wanshsan was polluted due to mercury mining and ore processing whereas in Quingzhen, mercury pollution initiates from chemical industry through discharge of waste-eater and emissions into the atmosphere because of coal burning for production of electricity. Through the research, it has been confirmed that there is large quantity of mercury in soil, sediments and air in mercury mining areas and the concentration decreases with increase in distance from the source. In spite of the sources of mercury being inorganic in nature, there is been found active transformation of the inorganic form in organic form in the water, sediments and soil in the two provinces mentioned above. The concentration of mercury in rice can reach up to 569microgm/kg of total mercury of 145microgm/kg is methylmercury.The variation in percentage from mercury to methylmercury varied from 5-83% (Horvat, 2003).

According to another study, depositon of mercury from air and diffuse release from the waste products are major causes of mercury pollution on soil ..Example of waste products include, batteries, switches, and medicinal waste, intended or unintended local releases from industry, spreading of sewage sludge co-release of maintaining contaminants on areas under cultivation, disposal on landfills, use of solid products from waste incineration, and coal combustion as construction material or decomposition of bodies with amalgam fillings (Stephen Bose O-Relly, *et al*. 2011)

3.3.4Air

Human hair has been a very useful tool for investigation of mercury exposure in the population from Wushuan mercury mining area (WMMA), Guizhou, Chaina. In order to measure human risk to mercury exposure, the total gaseous mercury (TGM) in the ambient air and mercury in rice were measured. It has been found that TGM level is comparatively higher in adjacent to the smelting workshops. From a reliable survey, it has been found that rice not only consisted of total mercury which was in between 6.0-112ng/g, but also was rich in methylmercury(Me-Hg) ranging from 3.1-4ng/g. Eventually, the hair total mercury concentration were found to be 33.9microgm/g and 21.5microgm/g at YQG and JZC sites, respectively. A certain level of mercury exposure also reflects from residents from other regains. There was no significant difference in hair mercury level due to age-variation. However, the total hair mercury concentration in male was more due to their occupations and rice consumption. The main route of inorganic mercury has been identified to be inhalation of Mercury polluted air for smelling workers and nearby dwellers, who are potentially under threat of accumulating methylmercury in their body due to consumption of rice (Feng, et.al., 2008).

Apart from fish, there are other factors that influence the methylmercury concentration in the body of the people. That was why a study was carried out to trace out the actual media of mercury exposure in the Chinese population among air, water, agricultural products etc. (Zhang, *et al*. 2010)

3.3.5Dental Amalgam

According to the information of the World Health Organization (WHO), the most important source of inorganic mercury in general people is dental amalgam. It has been found that the total mercury level is significantly higher in subjects with more occlusal amalgam surfaces (>12) compared with those with less number of occlusal amalgams (1-3) in all types of tissues. From a study on eighteen cadabars from routine autopsy casework, the total mercury from tissue level in brain, thyroid and kidney samples was measured using atomic absorption technique. Mercury level is relative higher in brain tissue than thyroid or kidney

tissues in subjects having more than 12 occlusal dental amalgam instead of those having 3 or less than 3 occlusal amalgam (Guzzi, *et al*. 2006).

At first, dental amalgam contained 50% if mercury. Studies suggest no association between the exposure from amalgams and health condition of children.Yet, it emits mercury vapor into atmosphere upon cremation of dead bodies (Stephen-Bose O Relly,2011)

Mercury vapor is mainly absorbed through the respiratory route.\Studies on humans suggest that about 70%-85% of inhaled mercury vapor is absorbed by the lungs into the bloodstream. Furthermore, it has been demonstrated that mercury vapor crosses the pharynx to reach the brain via the olfactory neuronsChildren inhale mercury vapor through dental amalgam fillings (Stephen-Bose O Relly,2011).

3.3.6Medicines

Example of a traditional medicine is cinnabar (HgS) in which total mercury level is estimated in cinnabar-containing medicine, such as Zhu-Sha-An-Shen-Wan (ZSASW). Adult Sprague-Dawley rats were gavaged with ZSASW (1.4 g/kg), cinnabar (0.2g/kg), $HgCl_2$ (0.02 g/kg), MeHg (0.001 g/kg), or saline daily for 60 days, and poisoning effect was resolved. Animal body-weight gain was reduced by $HgCl_2$ and MeHg. MeHg raised the Blood urea nitrogen (BUN).Following MeHg and $HgCl_2$ treatments, the histological studies report of kidney injury . Such impact is mild after ZSASW and cinnabar administration. Noticeable rise in concentration Hg was found in the $HgCl_2$ and MeHg groups but were not raised in the ZSASW and cinnabar groups. The expression of kidney injury molecule was increased 50-fold by MeHg, 4-fold by $HgCl_2$, but was unaltered by ZSASW and cinnabar; the expression of matrilysin was increased 3-fold by MeHg. In contrast, the expression of N-cadherin was deducted by $HgCl_2$. Thus, $HgCl_2$ and MeHg, indicates more nephrotoxicity than ZSASW and cinnabar. The different chemical forms of mercury underlie their disposition and toxicity (Shi, *et al.* 2911).

Since 1950s, Thiomerosal (sodium ethylmercurythiosalicyclate or thimerosal), which contains 49.6% ethylmercury,has been used to preserve vaccines. It is less threatening to health as ethylmercury does not accumulate and is actively excreted via the gut.Thealarms were raised in 1999 about the cumulative amount of mercury in infant immunization

schedules. In 2006 the WHO Global Advisory Committee on Vaccine Safety settled that current immunization practices does not need to be changed. However,information on preterm and malnourished infants has been continuously revised to find valid reasons,Usage of elemental mercury in some treatments, beliefs and activates (e.g. Santería, Espiritismospecifies health hazard due to exposure It may be due.to the practice itself or from accidental leaks. Still, the level of danger could not be estimated.

According to the suggestion WHO Guideline , the mercury concentration should be as follows: Water: 1 µg/L for total mercury Air: 1 µg/m^3 (annual average) WHO estimated a tolerable concentration of 0.2 µg/m^3 for long-term inhalation exposure to elemental mercury vapour, and a tolerable intake of total mercury of 2 µg/kg body weight per day. Health

Autism can be defined as a disability in development of social interaction and communication. Still the causes of autism has not been discovered.According to a relevant study, it has been found that there is relation between mercury exposure and autistic features. The blood and hair mercury level were measured and compared with the values obtained from a control group of similar 2- 10 years old children. After inclusion of DMSA, a chelation agent in the blood of the autistic children, much improving in their behavior has been seen as their autistic features declined (Yassa, 2004).

In the list of 40 Toxic Substance, mercury has been designated majorly as a toxic substance. For thousands of years, cinnabar, that is, mercury sulfide has been identified as a traditional medicine and has been used as an constituent in severalmedications. Even today, cinnabar containing medicine is in use. There is little information regarding toxicology and toxicokinetics of cinnabar and cinnabar-containing traditional medicine. High concerns of people has been found due to high mercury levels in these Chinese medicine. Heating cinnabar produces vapor that results in toxicity similar to the mercury vapor. Cinnabar can produce neurotoxicity only at concentration of 1000ppm more that of methylmercury. Long-term of use of cinnabar can cause renal dysfunction. Antidote for mercury poisoning, including cinnabar are Dimercaprol and Succimer Cinnabar is a medicine found in traditional Chinese and Indian Ayurvedicmedicine(Lui,*et al*. 2008).

Mercury along with lead and arsenic, has been detected in significant amount in Indian traditional Ayurvedic medicine, Mercury may be existing due to the preparation of rasa Shastra (containing herbs as well as metals, minerals and germs. It is still not known if noxious metals are extant in both US and Indian manufactured Ayurvedic medicines. (Saper, *et al*. 2008).

Western medicines do not consider mercury to be a medicine because of its poisonous impacts. However, Indian and Chinese traditional practice believe mercury-based formulation to have potent therapeutic efficacy while there is unique and repeated purification during preparation.Lack of proper pharmacovigilance and widespread self-medication has led to undesirable effects to certain sections of consumers of this medication. This has led to negative impact on these medicines. Variation in lack of storage and differences in recommended dosage and strategies is not understood properly in traditional medicines. These factors generate concern regarding safety and efficacy regarding traditional medicines in Western World (Kamuth, *et al*. 2012).

In another relevant study, the level of nephrotoxicity caused by cinnabar (MgS) has been compared with other medications containing toxic metals by administering the medicines to the mice.After study of six weeks, the animals' body weight has decreased and the blood urea nitrogen and creatinine level showed increased concentration of MeHg (Lu, *et al.* 2012).

According to another dependable source, there a research has been conducted to assess the level of cinnabar included intraditional medicines, such as, Zhu-Sha-An-Shen-Wan (ZSASW). Adult rats have been gavage with cinnabar, ZSASW, $HgCl_2$ and MeHg or saline for 60 days to judge the toxicity level of each kind of medication. Animal's body weight gain reduced by MeHg and $HgCl_2$. Blood urea nitrogen was augmented by MeHg. Treatment using MeHg and $HgCl_2$ led to severe kidney tissue damage unlike ZSASW and cinnabar, as shown by histological studies.Therefore, the ZSASW and cinnabar are relatively less nephrotoxic than MeHg and $HgCl_2$ (Shi, *et al*.2011).

A patent traditional Chinese medicine is An-Gong-Niu-Huang-Wan which is useful against brain disorder(Lu, etal., 2011). It constitutes of 10% HgS (cinnabar).Mercury is known to

produce toxicity to kidney,brain and liver.In order to find out if AGNHW is safe for hepatic tissue due to consumption of the medicine over a long period of time the rats were given cinnabar,connabar-containing AGNH orally for 44 days. The level of liver toxicity was compared with that of MeHg and $HgCl_2$.The serum aminotransferase level increased for MeHg and $HgCl_2$. Histopathological study states more liver damage in MeHg and $HgCl_2$-treated mice rather than those treated with cinnabar and AGNH (Lu, *et al*. 2011). Ethylmercury is the second source of mercury in health care is multidose activated vaccines as a preservative (Stephen-Bose O-Relly, 2011)

Mercury, in elemental and inorganic forms are used in some old-styleremedies and religious performs, for example, Santeria or Espritismo or Ayurvedic medicine. Following different traditionsburning of mercury in a in a candle, extending in the room, bearing as a talisman, or using in another manner.. Heavy metal poisoning with mercury, has been reported from variable sources from Ayurvedic medicine, which is used for children and adults. (Stephen-Bose ORelly,et.al., 2011)

3.3.8Cosmetics and Skin-lightening Creams

Mercury and mercury salts, including mercurous chloride and mercurous oxide, are restricted to use in cosmetic products as skin-lightening agents because of their hightoxic effect. Yet, there are enormous consumers of these products.

The content of mercury and low water-absorption property of the skin are two prime factors determining the rate of absorption of cream. The level of absorption through skin differs with the integrity of skin and how much soluble the lipid is in the vehiclein the cosmetic products. Ingestion may occur after topical application around the mouth and hand-to-mouth contact. Following absorption, the distribution of inorganic mercury takes place to different organs and primary means of elimination is through the urine and feaces.However long-term exposure of mercury, eliminates the metal through urinary pathway.. Its half-life is close to1-2 months.

The kidneys are the significantly deposits inorganic mercury; renal damage is characterized by reversible proteinuria, acute tubular necrosis and nephrotic syndrome. Gastrointestinal symptoms include a metallic taste, gingivostomatitis, nausea and hypersalivation. Inorganic

mercury can poorly penetrate through the blood brain barrier but, exposure for long-term can lead to increase in inorganic mercury in central nervous system (CNS) and neurotoxicity. Inorganic mercury toxicity immediately after use of skin-lightening creams has been highlighted from Africa, Europe, USA, Mexico, Australia and Hong Kong. Nephrotic syndrome (mainly due to minimal change or membranous nephropathy) and neurotoxicity were the most common presenting features. Therefore, restreictions should be brought on the use of mercury in cosmetics products.Publicly awareness should be built against use of such products as systemic absorption and accumulation of mercury causes renal, gastrointestinal and CNS toxicity (Chan,2011).

A relevant survey reported that the known ground behind nephritic syndrome and underlying renal pathology is mercury., 4 minimal cases use of mercury containing skin-lightening cream over 2-4 months is mentioned here. Regarding to renal pathology, apart from membranous nephropathy, minimal change disease should be included as another pathological entity caused by mercury exposure or intoxication. The mercury content of the facial creams was very high (7,420 - 30,000 parts per million). All patients were female and presented with nephrotic syndrome and heavy proteinuria (8.35 - 20.69 g/d). Respective values for the blood and urine mercury levels were 26 - 129 nmol/L and 316 - 2,521 nmol/d. Therefore, mercury-containing skin lightening cream is deleterious because skin absorption of mercury can cause minimal change disease. The public should be warned of the danger of using such products. In patients suffering from nephrotic syndrome, a detailed history should be taken, including the use of skin Tang, *et al*. 2013)

Another research suggests that a 34-year-old woman developed nephrotic syndrome after using a skin lightening cream that is manufactured of a high concentration of mercury. Blood and urine mercury levels were raised, followed by renal biopsy revealed minimal change disease. Membranous nephropathy was excluded using immunofluorescence and electron microscopy. Her proteinuria remitted 9 months after she avoided using the cosmetic cream. It is important that mercury toxicity because of cosmetic cream is considered in the differential diagnoses for any woman who displays nephrotic syndrome (Tang,*et al.* 2008).

3.3.9Paints, Mining Industries

Before 1982, the formulation of latex paint consisted of mercury (Hg) as phenylmercuric acetate (PMA). Hg vaporizes and reduces its content. A reliable study refers to level of Hg in latex paint coatings from both interior and exterior surfaces. Mercury chips has been collected from 40 homes of metropolitan New Orleans, USA for the analysis of Hg. Median Hg in exterior paints is four times more than for interior paints. Median lead (Pb) in exterior paints is 184 times greater than interior paints Due to the affinity of Hg for sulfur-containing amino acid proteins, their prevalence in paint coatings indicates an increased hazard when released as dust (Melke and Gonzales, 2008)

A dependable source describes the mercury contaminated sites in Asia. In comparison to other regions, Asia contributes more anthropogenic mercury in atmosphere and it is responsible for more than half of worldwide mercury emission. Depending upon the different sources, the mercury polluted sites in Asia were categorized into various types, such as Hg pollution from Hg mining, gold mining, chemical industry, metal smelting, coal combustion, metropolitan cities, natural resources and agricultural sources. Reviewing through a large number of research paper, extreme level of Hg pollutions to the surrounding environment were found in the area influenced by chemical industry, mercury mining and gold mining. With the probable effects of a unique combination of climatic (e.g. subtropical climate), environmental (e.g. acid rain), economic (e.g. swift growth) and social factors (e.g. high population density), more effort is still needed to explicate the biogeochemistry cycle of Hg in association with health effects in Asia (Li,*et al.*2009).

A similar paper suggests coal-combustion, steel-production and gold-mining industries are factors responsible for escalating level of mercury in the atmosphere.Besides, the electrical and electronic industry exists as a user and a contributor of mercury.Similar effects are shown by the phenomenon of disposal of electrical and electronic wasters.Additionally, to up-rising anthropogenic Hg emissions in Asia, associated environmental and health implications may also exacerbate in the region for the probable effects of a unique combination of climatic (e.g. subtropical climate), environmental (e.g. acid rain) and socioeconomic factors (e.g. high population density) (Wong, *et.al*. 2006).

Another study suggests that inorganic mercury is added for skin-lightening effects into cosmetics Dermal absorption of phenyl mercury from contaminated diapers affected urinary excretion in infants in Buenos Aires.

Mercury-containing preparations are used in many areas of the world, including China, Central and South America, Africa, and the Middle East. The mercury in these preparations is absorbed through the epidermal layer of skin can lead to systemic toxicity and there are reports of nephrotoxicity (including nephritic syndrome), dermal toxicity, and neurological toxicity associated with their use (Stephen-Bose ORelly, 2011).

3.3.10Thermometer, Barometer and Sphygmomanometer

The mercury containing devices, such as, thermometers, sphygmomanometers, some barometers, manometers thermostats etc. are other sources of mercury. These instruments are hazardous to use in hospital environment as they contain mercury vapor that may be released upon breakage. Despite fall in production for mercury-containing thermometers, they are still demanded. Non-mercury thermometer's use is increasing day-by-day. thermometers are now widely accepted. (Stephen-Bose O-Relly, et.al.2011

3.3.11Fluorescent lamp, Batteries (Choir-alkali) and Bottom-cell) and Switches

\Since past few years, use of compact florescent lamps has increased surprisingly. The appeal of compact fluorescent light bulbs is due to their significant increased energy efficiency (75%) compared with incandescent light bulbs and their greater lifespan of use. A compact fluorescent light bulb can be used over a time period of 10 times more than an incandescent lamp.During the hour immediately following the break of a compact fluorescent light bulb, the level of mercury vapor raises200 and 800 $\mu g/m^3$. The average 8-hour occupational exposure limit allowed by the US Occupational Safety and Health Administration is 100 $\mu g/m^3$. A new 13-watt compact fluorescent light bulb releases about 30% of its mercury over a time of 4 days with the remaining mercury staying in the bulb debris. Following breakage, clearing of the glass debris, reduced mercury release by approximately 70%. Similar trends are fond in second-hand bulbs as brand-new bulbs but with lower rates.The risk can be put into perspective somewhat by considering that a power plant produces 10 mg of mercury to produce the electricity needed to light an incandescent

bulb, while a compact fluorescent bulb contains 2.4 mg of mercury. In short, the shifting to compact fluorescent light bulbs over incandescent bulbs is a lower net effect of overall mercury in the atmosphere. Without any dispute over the life-cycle analysis terms of a net reduction of environmental impact;, there is the public health issue of preventing direct exposure to children in a home if a bulb breaks in the household (Stephen-Bose O-Relly,2011).

Other important sources of mercury were the coal-power stations and burning of fossil fuels, mining of gold and silver, zinc-smelting, incineration of landfills and cremations. Mercury is also found in pesticides and biocides(Ruth and Carter, 2005).

3.4 Pharmacokinetics of Mercury

3.4.1Elemental Mercury

Consumption through eating, elementary mercury is sparingly penetrates, at least 0.01% of the dose, in the gastrointestinal tract. These occurrences may be in the case of accidental swallowing of the elemental mercury, for example, brakeage of thermometers. It is rarely expected for systemic toxicity to occur. However, a difficulty in the gastrointestinal tract may bring changes in the mucosal barrier and allow the increased bioavailability. Minimal absorption of elemental mercury takes place through the skin (Park and Zheng, 2012).

Through inhalation, about 80% of metallic mercury vapor released from amalgams is enters bloodstream compared to about 7-10% absorption of orally consumed metallic mercury and about 1% of absorption of metallic mercury through dermal route. Upon entering the body mercury vapor has attraction for sulfhydryl groups and attaches to sulfur-containing amino-acids throughout the body.Mercury vapor is carried to the brain being dissolved in the serum or in the red blood cell membrane. Metallic mercury easily crosses the blood brain barrier. It can also penetrate the placental barrier in a pregnant woman to accumulate in the fetal brain. Metallic mercury is however rapidly oxidized to mercuric mercury on entry to blood-stream. This does not happen as fast as metallic mercury to prevent considerable uptake by the central nervous system as in metallic form (Bernhoft, 2011).It is noticeable that the elementary mercury can cross the mucous and connective tissue of nasal cavity, and from

there it can be coveyed to the brain via the olfactory system of brain, named the olfactory pathway (Park and Zheng, 2012).

Additionally metallic mercury is also accumulated in the thyroid, breast, myocardium, muscles, adrenals, liver, kidneys, skin, sweat glands, pancreas, enterocytes, lungs, salivary glands, testes and prostate and may be related to impairment of those organs.Mercury also has attraction for attachment with the surface of the T cells and the sulfhydryl groups manipulating T cell functions Mercury readily is collected in the placenta and the fetal tissue and is excreted in the breast milk (Bernhoft, 2011).

Metallic mercury is largely excreted in the mercuric mercury.The excretory half-lives of metallic and mercuric mercury concentration as vastly dependent on the organ on which it is deposited and the redox state, with time period varying from few days to several months, including some pools, e.g., CNS having a half-life of several years Hair mercury concentration has no relationship with mercury concentration in brain.

Brain and kidneys are the crucial organs of mercury cumulating following inhalation exposure to elemental vapor. After exposure, the greater percentage of body burden of mercury is gradually found in the kidney which similar to other inorganic mercuric compounds.Urine and feaces are the major means of getting rid of mercury although a small amount of mercury can evacuated in breathe, saliva and sweat. The dose of mercury determines its elimination pattern. It is also biphasic that is initially \fast followed by a slow-reaction. Mercury has a biological half-life of around 30-60 days. Though the half-life of mercury in the brain could not be clearly estimated, it is assumed to be about 20 years (Park and Zheng, 2012).

3.4.2Inorganic Mercury:

Following ingestion, about 7 to 15% of the doses of inorganic mercuric compounds aretaken in the gastrointestinal. Tract.Absorption of inorganic mercury through skin is possible Such intoxication may take place depending on the level of use of products, e.g., cosmetics containing inorganic mercury salts. It has also been traced out that inorganic mercury may be pass through the dermal route by absorption of mercury through epidermal and sweat glands, sebaceous glands and hair follicles. Rarely, mercury poisoning occurs through

inhalation as mercury salts are non-volatile. Calomel contains mercurous mercury that is hardly dissolves in water and sparingly passes through the intestine. Some gets oxidized in the absorbable form. Doubtfully, mercurous mercury exists in its transitional form in between metallic mercury and the mercuric mercury.

3.4.3Mercury in Mercurous Compounds

Initial absorption of ingested mercury is only about 2%. It is still pressumed that its eroding effects in the intestine may increase penetrability.Thereby;more mercury is being absorbed due to long-term exposure. Distribution of mercuric mercury is similar to metallic mercury. Like metallic mercury, mercuric mercury adheres to the sulfhydryl group on erythrocytes, metal-albumin or glutathione or suspended in the plasma. The blood brain barrier prevents efficient movement of mercury across it but it accumulates abundantly in placenta, fetal tissue and amniotic fluid. Evidence exists showing transport of mercuric mercury to one or more amino acid transporters, for example the cysteine which may account for accommodation in the brain. Much of the body burden of mercuric mercury resides in the convoluted renal tubule bonded to metal-albumin. Mercury is prominently deposited in is in the liver and lesser amounts in epithelial tissue, choroidal plexus and testes.

Mercuric mercury is largely excreted through urine and stool although large amounts are shed through sweat, tears, breast milk and saliva. Half \lives take place in multiphases as with metallic mercury according to the results of clinical trials and effective half-life of 42 days for 89 % o total tissue dose, the other 2-% did not appear to have a reasonable rate of excretion. This may be because of its demethylation to metallic mercury to the brain and other organ mechanisms to be determined.

3.4.4Organic MercuryCompounds

Methylmercury is the most familiar form of organic mercury. It is a principal means of humans to mercury exposure. It is available naturally in fish and comparatively stable . Methylmercury and ethylmercury have similar mechanism of action . The latter has an excretory half-life of 30% of the previous one.

Like metallic mercury vapor, methylmercury vapor is also uptaken by 80% efficiency. Intestinal absorption of methylmercury from fish is also fairly efficient as absorption through the skin. Upon entering the bloodstream, methylmercury adheres to sulfhydryl group, particularly to those in cysteine. Deposition of methylmercury takes place throughout the body and it equilibrates between blood and body occurring approximately from the time after exposure.Distribution to peripheral tissue seems to occur through one or more transporters especially cysteine-transporters probably adherent to sulfhydryl groups in cysteine/

Accumulation of the methylmercury occur in the brain, liver, kidney, placenta and fetus especially in the fetal brain and also peripheral nerve and bone marrow. After deposition the methylmercury is de-methylated to inorganic mercury/.

Efficient dermal absorption of Dimethylmercury is also noted and there is a reported death of scientist causes by minimal dermal contact.

The half-life for excretion of methylmercury is approximately 70 days, with around 90% being excreted in stool.Apparently some degree of enterohepatocytes circulation takes place. Probably, 20% of methylmercury is excreted in breast-milk but the actual amount depends on the level of exposure. Hair mercury reflects blood mercury at the time of incorporation but not elemental mercury.Therefore, it is not a suitable indicator of body burden provided the short half-life of methyl mercury in blood.

3.5 Pharmacodynamics of Mercury and Harmful Effects on Human Health

Inhalation of the elemental and methylmercury is lethal to human health. Harmful effects on nervous system, digestive system, immune system are results of mercury vapor inhalation, including fatal impacts on lungs and kidneys (Gibbs, *et al*. 2014).

Solubility of mercury salts determines their level of toxicity. In general, mercurous compounds are relatively leas poisonous than mercuric compounds (Park, 2012).

Mercury salts pose relatively greater acute health effects than elemental mercury, upon ingestion. An adult may die upon consumption of 1-4g of mercury. Due to more corrosiveness of mercury salts, these have higher permeability and absorption than

elemental mercury. An acute high dose exposure of mercury salts primarily cause burning chest pain, discoloration of oral mucous membrane. Further exposure may cause severe gastrointestinal symptoms due to corrosive damage to the gastrointestinal tracts and following symptoms and signs of mercurcuric stomatitis and impaired kidney functions. Irritationsto the skin that cause dermatitis, staining of nails, deterioration of mucous membrane, may cause corrosive burns. These are also consequences of mercury poisoning.Rarely, exposure may take placethrough inhalation because of their solid and non-volatile state at room temperature (Park, 2012) The acute syndrome of mercury salt poisoning is stomatitis or digestive upset, Mercury salts are very toxic to the kidneys causing acute tubular necrosis, immuno logic glomerunephritis, or nephritic syndrome. Therefore, frequent exposure leads to kidney damages. Chronic exposure primarily involves CNS, primarily causing the ultimate damage. The symptoms of chronic toxicities include progressive anemia, gastric disorders, salivation, metallic taste in the mouth, inflammation and tenderness of gums and tremors. Mercury salt exposure may also be responsible for central neuropathy, such as, \exposure of infants to mercury calomel powder containing mercurious chloride. Some examples of severe level of toxicities of mercury compounds are darkening and loss of teeth. Renal complicacies with excess changes in behaviors are common symptoms. (Trichouneu, 2003).

Seldom, chronic mercury poisoning occurs and it is found in case with pure organic mercuric salts. The target organ toxicity from organic mercury is kidney damage, mainly in the proximal convoluted tubule. The polyuria and proteinuria are the common clinical signs and symptoms. The low molecular proteinuria is more prevalent thatleads to into nephritis syndrome. In severe cases, hematuria and anuria may appear. Despite no investigation on the mechanism of poisoning, it is taken for as a type of hypersensitivity reaction. Perhaps, deposition of mercury chloride on tissue causes Acrodynia.A Korean 3 years-old boy was reported after exposure to house paints and lacquer for 2 months. Organic mercury salts do not dissolve in liquid. Thereby, they normally cannot penetrate the blood brain barrier. Insignificant toxicities have been observed following consumption for a fit person because the metal doses are hardly permeable in the gastrointestinal tract. Absorption efficiency is as low as 0.01%.

Exposure to methylmercury is themost fatal form of mercury to human physiology. Itdistresses brain development making lower IQ. The prolonged social expenses can configure by a lifetime causing loss per person. The extreme dose does not estimate other prospects of brain toxicity or the chances of cardiovascular diseases in adults. Since methylmercury is formed, it in cycles through the atmosphere . It has beeneras of unveiling humans and other species as toxic forms of generation(European Commission, Science for Environment Policy, 2015).

Additionally, toxicity of methylmercury has also been found for centuries. Its neurotoxic effect has been mainly found in children. It prevents the in vitro microtubule formation and protein synthesis in neurons, changes membrane activity and upsets DNA synthesis. Impairment of mitotic process occurs.Neuronal migration is being hampered. Prenatal and postnatal exposure to methylmercury adversely that affects the CNS but it seems to be most neurotoxic at the primary stage of brain development.High levels of methylmercury in brain can lead to cerebral palsy, seizures and ultimately death. The exposure of organic mercury compounds depend on the specific compounds, route of exposure, dose and age of the person when being exposed. Ingestion of mercury can be lethal due to gastrointestinal ulceration, perforation and hemorrhage. Destruction of intestinal mucosal barrier leads to excessive mercury absorption and delivery to the kidneys leading to seriousrenal injury. The nervous system is most susceptible to mercury poisoning than any other parts of the body. Arrhythmia and cardiomyopathy may also occur from mercury poisoning. Studies on hair of cases with mercury-induced cardiomyopathy scaled mercury contents 20,000 higher than in controls. Other neurological problems such as, tremors, insomnia, polyneuropathy, parenthesis, emotional lability, irritability, personality change, headache, weakness, blurred vision, dysarthria or speech impairment, slowed mental response, and unsteady gout have been observed (Trichouneu, 2003).

Mercury is one of the metals that have strong cytotoxic effects on cells, particularly the cells for immunity.

3.5.1 1ffects on Infants

Inorganic mercuric toxicity occurs in children who use teething powder containing mercury compound that is calomel which was described as acrodynia or pick disease. The case is characterized by profuse sweating and erythematous rash of palm and soles,painful sensitivity to touch, anorexia, fatigue, irritability, apathy, photophobia and polydipsia. (Park, *et al*. 2012). Enhanced hypotonnia, itching, burning and severe pain of the extremities, alopecia, ptylism or profuse secretion insomnia, apathy and irritability have been observed in children (Trichouneu, *et al*. 2003).

3.5.2 Effects on Adults

The total lethal dose is 100g for a 70kg adult. Dermatitis is the consequences of acute elemental mercury exposure. Parental exposure to elemental mercury can lead to lical and systemic effects of mercury poisoning. Elemental mercury self-injection in the artecubitalfosa is the result in subcutaneous granulosa. Mercury embolism is the consequence following intravenous injection of mercury. Acute exposure to high concentration of mercury can lead to hypoxic condition of lungs resulting in death, Acute poisoning by mercury vapor inhalation usually occur unintentionally to industrial workers who are exposed to high concentration of mercury vapor accidents. These accidents could also occur when elemental mercury is accidentally vaporized in a confined and to anelevated temperature environment in industry or at home. Acute response to mercury vapor inhalation can cause central nervous system toxicity , such as, tremor, paresthesia, memory loss, hyper0reactivbity, erthism, and delayed reflex which are commonly reversible (Park,*etal*. 2012).

Pneumonitis is the aftermath of inhalation of evaporated mercury vapor. Acute necrotizing bronchitis is the result of high levels of mercury exposure. It also causespneumonitis with symptoms of cough, dyspnea and chest tightness. Diffuse infiltrates seem in early chest radiography progress to pulmonary edema, respiratory distress and desquamation of bronchiolar epithelia that can end in death from respiratory failure. Commonest signs of toxicity in children are diffuse pruritus rash and dermatitis. Acrodynia, is claimed to be rash due to anidiosyncratic hypersensitivity reaction on exposure of mercury It matures to be

sore, not well-defined erythematous papulovesicular eruption with efema and induration of the palms, soles and face. This progresses over a period to desquamatous ulceration often along with diaphoresis and increased blood pressure and heart rate. Patients complain of aching back tremor and urination. Poor sleeping, sore throats, night sweats and sweating when red hot and noted symptoms. First a painful grain preceded by particular folliclesis found in adult cases.Extreme level of constipation and significant changes are also found in adults (Trichouneu, *et al*. 2003).

The catalase enzyme within the blood converts the elemental mercury to mercuric ion (Hg^{2+}) uon inhalation or dermal contact of elemental mercuy. The blood brain barrier cannot be penetrated by these mercuric ions. This means their diffusion out of bran has completely reduced. CNS defects are caused by long-term exposure to mercury. Such signs includes insomnia, anorexia, forgetfulness and mild tremor. Combined exposure leads to progressive tremor and erythrism, a syndrome characterized by intention tremor, excitability , memory loss, insomnia, timidity and sometimes delirium and once commonly in workers exposed to mercury in the felt-hat industry Red palms, emotional liability, salvation, excessive sweating and hemo-concentration are accompanying peripheral and autonomous sign. Trichouneu, Ayansu, NIrashbili, *et al*. 2003).\

3. 5.3 Neuro-behavioral Effects

The maternal exposure to mercury controls the neurodevelopmental effects in a fetus are connected with maternal exposure. Neurocognitive deficits and neuro-motor disabilities may also because by mercury. In 3 widespread epidemiologic studies among fish-consuming population, the mother-child pairs have been brought into study and the subsequent effects on child development. The Seychelles child development study examined 779 mother– child pairs who experienced a permanent low-dose exposure to methylmercury during their prenatal life.The exposure was due to continuous seafood consumption. The mercury level in maternal hair reflected the amount of exposure of children to the metal. Neuropsychological tests were performed at the age of 9. Developmental signposts and neurodevelopmental conclusions using consistent trying batteries were inspected across 5

stages of age of the children. However, no undoubted evidence was found to support the study thesis of adverse effects on children due to consumption of fish contaminated with methylmercury.

In New Zealand, a study was carried out on 38 children of mothers who had a mercury level higher than 6 ppm. (6 µg/g hair) during pregnancy. The survey was carried in order to draw a comparison with a group having lower content of mercury in hair.237 children of age 6 were examined with a method similar to the Seychelles study, a relationship between dose and neuropsychological endpoints has be found. Similar outcomes came from the study in the Faroe Islands wheredose-related effects were found.

The Faroe Islands cohort included mother– child pairs. In contrast, other 2 studies involved their consumption of whale meat in an episodic manner.Maternal hair and cord blood were the determining factors for mercury exposure. At 1 year of age, children were examined for milestoneand at 7 years of age the children were far neuropsychological observed. In between 1987-1988, a cohort on 1022 children was exposed to methylmercury. The mothers frequently fed on initial whale meat, which is potentially high in methylmercury. Another group continuously ate fish with a comparably lower methylmercury concentration. At age of 7 and 14, neuropsychological tests were carried out, displaying neuropsychological dysfunctions mainly for language, attention, and memory, and less for visuospatial and motor functions. Neurophysiologic tests showed delayed brainstem auditory-evoked and potentialsdecreased autonomic heart rate variability both of which are consequences of prenatal exposure. The overtone remained after regulating for perplexing variables and without children from mothers with increased hair mercury concentrations (>10 µg/g), indicating that negative effects can be found at levelsopreviously taken for to be safe

The Minamata outbreak shows high burden of the population with methylmercury upon feeding of seafood. Besides neurodevelopmental and neurocognitive impairment, other symptoms, such as vision impairment, paresthesias, neuralgias, dermographism and impairments of taste, smell, and hearing, as well as seizures leading to death even if the fetus is exposed to a high level of methylmercury. Intrauterine

and early neonatal death have also been observed.Similar symptoms in adult patients were discovered after the outbreak of mercury poisoning in Iraq caused by contaminated seed grains.

Healthy diet constitutes in seafood including fish. It is beneficial for pregnant woman to consume fish which is comparatively rich in omega-3 polyunsaturated fatty acids (v-3 PUFAs).This nutrient is rarely available in other foods. It is also contains proteins that are essential for the emerging fetal brain. The prime demerit of fish consumption for pregnant mothers is that some species of fish contain organic mercury at sufficiently high concentrations to cause severe harmful developmental effects to the fetus Methylmercury, the most injurious form of environmental mercury to humans; It is synthesized from inorganic mercury by the action of anaerobic organisms found in the aquatic environments. Methylmercury is a prominent neurotoxic ant in humans that can have seriously harmful effects on the central nervous system, particularly when the fetus develops. Due to its lipophilicity, methylmercury immediately crosses the placenta. Therefore, it is found at higher concentrations in the fetal and maternal circulating blood. Hence, concern arises whether pregnant women should consume fish or not. The main target tissue for methylmercury is the brain where the division and migration of neuronal cells are inhibited and cytoarchitecture is disrupted. The incidents of Minamata and Iraq bear the best proof for fetal brain poisoning with mercury. Using data collected after the disaster in Iraq, it has been defined that the edge toxicological levels linked with adverse effects to the fetus as low as 10 mg/g in maternal hair.Though a place to start in the valuation of dose–response of fetal damage by mercury, this threshold was based on clinical evidence of neurologic damage . It is not dependent on current neurodevelopmental testing techniques. From dissection of cadabars in cases from Iraq showed that neuronal cell division, migration, and organization were hampered. The distribution of lesions in the central nervous system differsin the fetus from the adult brain. Prenatal exposure was associated with widespread lesions in the fetal brain, whereas adult cases had focal lesions mostly localized to the posterior portions of the brain and the cerebellum. For populations that are socioeconomically reliant on on fish consumption as a major dietary protein source, it is also judicious to consider the welfares derived from fish when evaluating the actual risk connected with methylmercury in fish eaten during pregnancy. Fish and other seafood contain advantageous nutrients such as v-3

PUFAs, which are essential for optimum neurologic development. At present, there is no conclusive evidence that such complements improve child neurocognitive accomplishments.

Though fish consumption is so beneficial for expecting women, they avoid the important diet because of the contradictory effect on source as a result of the history of these adverse methylmercury events. It may either be due to response to public health warnings about toxicological impacts of seafood on child neuro-development resulting from fetal exposure (Schoeman, *et al*. 2009).

3.5.4Nephrotoxicity

Inorganic mercury compounds are responsible for nephrotoxicity bringing about kidney damage in children. It mainly targets the proximal tubules of the kidneys. The tubular cells can partially renew. However, dangerous cases of inorganic mercury intoxication can lead to the function of the kidneys become reduced leading to death because of acute kidney failure.Upon urinary excretion, skin absorption of phenyl mercury occurs through dirty diapers in case of Argentinian infants. Among the amalgam exposed group, a research conducted on 534 children in the US showed a rise of microalbumin. Microalbuminuria excretion is an indicator of antagonistic kidney effects. However the other biomarkers did not show an effect (alpha-1-microglobulin, gamma-glutamyltranspeptidase, and N-acetyl-beta-d-glucosaminidase.

In gold mining areas, a study with adults and children displayed a relationship between mercury exposure and proteinuria.Kidney damage is the consequence of mercury poisoning. Evidently suggested associations between mercury exposure and acute tubular necrosis, glomerulonephritis, chronic renal disease, renal cancer and nephrotic syndrome have been found Numerous reports have proven that mercury exposure can lead to various kidney injuries including: subacute-onset nephrotic syndrome, tubular dysfunction, secondary focal segmental glomerulosclerosis, syncretistic nephrotic syndrome, nephritic syndrome, nephrotic-range proteinuria, glomerular disease, and membranous glomerulonephritis.

Thousands of medical lab tests and governmental species have recognized dental amalgam as the main source of mercury in most with amalgam dental fillings.In kidneys it si the principal source of mercury.Mercury gradually bio-accumulates there. Conducting a number of surveys on dental amalgam filling, it has been found that chewing on amalgam, and fish consumption are positively associated with Urinary-HgC. A statistical significance has been found between the number of amalgam surfaces and the mercury level in the renal (kidney) cortex. One study found levels ranging from 21 to 810 ppb. According to result of a study, levels in kidney donors found an average of 3 times higher mercury levels in those with amalgams versus those without. Studies revealed that the number of amalgam surfaces has a statistically significant correlation to urine mercury levelT

The mercury content in urine of dental personnels is twice as much as that of the controls. Swedish and European studies on amalgam suggests that maximum exposure to mercury takes place through dental fillings and its health effects are increased mercury level in urine of dental professionals .Hence, Sweden voted for elimination of mercury from dental fillings. Results of urine mercury level ranged from 0.8 to 30.1 ug/L with study averages from 3.7 to 6.2 ug/L. 5.6 nmol/L(11.6 ug/L) is the Swedish Safety Guidelines for urine mercury concentration.. Study averages for other countries ranged from 3.3 to 36 microgram/liter (µg/L). A large survey of dentists at the Norwegian Dental Assoc. meeting found that the mean mercury level in 1986 was 7.8 µg/L with approximately 16% above 13.6ug/L, and for 1987 found an average of 8.6 µg/L with approximately 15% above 15.8 µg/L, with women having higher levels than men in general (Rice, *et al*. 2014)

3.5.5 Teratogenicity

Methylmercury teratogenicity were possible in toxicologic studies using high doses of inorganic mercury compounds though at frequent exposure these effects have not be beheld.

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3.5.6Feto-toxicity

Mishaps, for instance, miscarriage, spontaneous abortions, stillbirth, and low birth weights are associated with feto-toxicity which can be the subsequent results of mercury exposure.. In the neonate, mercury exposure during pregnancy has been linked to neural tube defects, craniofacial malformations, delayed growth, and others. Mercury has the power to penetrate the plaveental barrier and it can inhibit fetal brain growthensuing in cerebral palsy and psychomotor retardation in the following stages of development In primates maternal MeHg blood levels were abstemiouslyrelated to amplified abortion rates and diminished pregnancy rates Embryopathic effects of MeHg in humans have also been reported. Fetal autopsies specified a widespread hypoplasia of the cerebellum, lessened number of nerve cells in the cerebral cortex, marked drop in total brain weight, abnormal neuron migration, and brain centers and layer deranged organization MeHg easily enters through the placenta and damages the brain of the fetus. Many exposed feti go on to develop infantile cerebral palsy and there may be a relation with the development of Minamata disease. Babies may be born with a variety of birth defects. A study of 64 children exposed in utero to mercury and showing mercury associated damage included the following signs and symptoms: mental retardation (100%), primitive reflexes (100%), strabismus (77%), cerebellar ataxia (100%), dysarthria (100%), chorea and athetosis (95%), deformed limbs (100%), hyper-salivation (95%), epileptic attacks (82%), and growth disorders (100%) [6].The trans-menmbrane transport of nutrients including selenium is disrupted across the placenta due to mercury. Studies on animals have brought the fact into light that mercury has tendency to accumulate in the fetal brain more than the maternal brain (Rice, *et al*. 2014).

3.5.7 Cardiovascular Toxicity

Upon exposure to methylmercury from sea-foods, the children experience alteration in heart beats. As sympathetic and parasympathetic modulation of the heart rate variability decreases, the association between methylmercury and cardiac effects are found. This may occur due to methylmercury neurotoxicity in the brain-stem nuclei. Aninvestigation among 274 Korean children put forth a link between urinary mercury concentration and an increase of cholesterol as a jeopardy factor for myocardial infarction and coronary or cardiovascular disease. According to the finding of another Korean research , cardiac autonomic activity

through parasympathetic dysfunction might be manipulated by mercury even at low-doses in the first and second decade of life. Information from the Seychelles study refers that prenatal methylmercury exposure might forecasthigher blood pressure levels for adolescents. Because of exposure from mercury-containing interior latex paint in the US a 4-year-old boy developed acrodynia, including tachycardia and hypertension. Association of methylmercury is found with hypertension among adults.

Cardiomyopathy is the resultant effect of mercury deposition in the heart.Actually, mercury concentration in cardiac tissue of a case, died from idiopathic dilated cardiomyopathy were discovered to be on average 22 000 times higher than in individuals who died of other forms of cardiac disease.People below the age 45 may experience chest pain or angina due to toxicity of mercury. Cardioprotective activity of paraoxonase can be inhibited as suggested by results from in-vitro studies..

3.5.8Carcinogenicity

In adults, prolonged exposure to methylmercury may lead to leukemia.The International Agency for Research on Cancer appraised the power of confirmation for carcinogenicity of mercury in a homogenous manner using information from animal and human research. Methylmercury compounds are categorized as possible carcinogens to humans (group 2B). Metallic mercury and inorganic mercury compounds were not classifiable with respect to their carcinogenicity in humans (group 3).No specific data on the cancer risk for children are available.

3.6.9 Genotoxicity and Mutagenesis

Probably, weak mutagenic property is found in mercury too. 3 Sister chromatid exchanges is significantly induced by thimerosal, representating a genotoxic and cytotoxic outcome of thimerosal in cultured human peripheral blood lymphocytes

3.6.10 Reproductive Toxicity

Mercury can demonstrate pathophysiological vicissitudes along the hypothalamus-pituitary-adrenal and gonadal axis .This may disturb reproductive function by shifting the flowing of follicle-stimulating hormone (FSH), luteinizing hormone (LH), inhibin, estrogen,

progesterone, and the androgens. Reduced fertility has been noticed among the dental assistants because of their occupational exposure. Studies in Hong Kong demonstrated that both males and females suffered from infertility problems due to high exposure to mercury, In males, mercury can unfavorably affects spermatogenesis, epididymal sperm count, and testicular weight. There are evidences that states that mercury is responsible for erectile dysfunction In females, mercury has been shown to prevent the release of FSH and LH from the anterior pituitary. Consequently, the release of estrogen and progesterone is being affected. Final effect leads to ovarian dysfunction, painful or irregular menstruation, premature menopause, and tipped uterus. Sufficient evidence have been found that links mercury with menstrual disorders including abnormal bleeding, short, long, irregular cycles, and painful periods (Rice, *et al*. 2014)

One reflective study examined the effect of methylmercury contamination on the sex ratio of offspring at birth and of fetuses at stillbirth. Due to the severe methylmercury pollution in Minamata, relatively less numbers of male offspring at birth were found. In Mamanta, the quantity of male stillborn fetuses augmented. This surveillance indicates that male fetuses could be more subtle. Abnormally low number of pregnancies resulted after out-break of mercury poisoning in Iraq . Occupational exposure of dental assistants to mercury leads to spontaneous abortions, stillbirths, and congenital malformations(Rice, *et al*. 2014)

Ovaries, testes, and prostate gland are regions where mercury may accumulate. Additionally, the estrogenic effects of mercury has other documented hormonal effects including effects on the reproductive system resulting in lowered sperm counts, defective sperm cells, incapacitatedDNA aberrant chromosome numbers rather than the normal 46, chromosome breaks, and depressed testosterone levels in males and menstrual disorders and infertility in women. Mercury has been found to cause reduced sperm capacity and motility, bigger sperm irregularities and spontaneous abortions, increased uterine fibroids/endometriosis, and decreased fertility in animals and in humans. In clinical studies miscarriages or birth defects, husbands were found to naturally have low sperm counts and significantly more visually abnormal sperm. According to an estimation 85% of the sperms is produced by a healthy male is DNA-damaged. Studies display the relationship that an increase in the rate of spontaneous abortions with an increasing concentration of mercury in

the fathers' urine before pregnancy. Sub-fertile males in Hong Kong were found to have 40% more mercury in their hair than fertile controls. Infertile males have releases of abnormal semen. Infertile females have shown unexplained infertility having a higher blood mercury concentrations than their fertile counterparts. The number of amalgam fillings was found to be an important factor in success of treating male infertility. From clinical experience, some of the symptoms of /mercury poisoning include frequent urination (Nanes, *et al*.2014).

3.6.11 Immuno-toxicity

Mercury is proven to be immune-toxic from studies on animals. A positive correlation has been found between mercury and malaria after investigating on mercury exposure in the Amazonian region due to gold mining activities. The New England children's Amalgam trial showed a significant immune-toxic effect in the form of a decline in responsiveness of T cells and monocytes at 5-7 days after treatment.

Klinghardt's axiom states that "Most, if not all, chronic infectious diseases are not caused by a failure of the immune system, but are a conscious adaptation of the immune system to an otherwise lethal heavy metal environment". Mercury depresses the immune-system via its harmful effects on the polymorphonuclear leukocytes (PMNs). Mercury through suppression of adrenocorticosteroids production prevents normal stimulation of PMNs production.Thereby, also affects PMN function by inhibiting their ability to destroy foreign substances. Individuals who are susceptible to mercury are more likely to have allergies, asthma, and autoimmune-like symptoms, especially rheumatoid-like ones. Mercury can produce an immune response in the central nervous system, induce alterations in immune cell production and function, and modulate the production of interferon gamma and interleukin-2. This sensitivity may lead to chronic sickness (Rice, *et al*. 2014).

Interestingly, the consumption of mercury is oftentimes related with increased levels of yeasts, bacteria, and molds. These micro-organisms are thought to function in a protective manner to absorb excess mercury from the body. Random use of antibiotics lead to indiscriminant and rapid destruction of *Candida albicans*and other pathogens in adults with a significant body burden of toxic metals.Hence,mercury may cause the sudden release of

large amounts of toxic metals present within them .This can be possibly very hazardous. Mercury body burden has also been related withoccupied in a number of immune or autoimmune conditions including allergic disease, amyotrophic lateral sclerosis, arthritis, autoimmune thyroiditis, autism/attention deficit hyperactivity disorder, eczema, epilepsy, psoriasis, multiple sclerosis, rheumatoid arthritis, schizophrenia, scleroderma, and systemic lupus erythematosus (Rice, *et al*. 2014).

3.7Preventive Measures against Mercury Poisoning

There are several ways to prevent adverse health effects, including promoting clean energy, stopping the use of mercury in gold mining, eliminating the mining of mercury and phasing out non-essential mercury-containing products. One way is too indorsethe use of faultless energy sources that do not burn coal. Coal richly contains mercury and other hazardous air pollutants that are emitted when the coal is burning coal-fired power plants, industrial boilers and household stoves.Removal of mercury mining, and use of mercury in gold extraction and other industrial processes are also important counteractive measures. A range of actions are being taken to decrease mercury levels in products, or to phase out mercury-containing products. In health care, mercury-containing thermometers and sphygmomanometers are being replaced by alternative devices.The 2009 WHO report states that the dental amalgam should replace the use of mercury with something else through further research and development of cost-effective means.Since thimerosal (ethylmercury) is used in trace amounts in vaccines , it is unlikely to cause poisoning effects .There should be governmental restrictions on manufacture and use of mercury-containing skin-lightening products.

CHAPTER:4

CONCLUSION

CHAPTER: 4

4. Conclusion

4.1 Limitations of the Study

Enough articles and journals of recent years were not available regarding every source of mercury. In addition, data in context of Bangladesh was not available in respect to mercury poisoning.

42 Policy Making Decision

In 2013, political agreement has been signed to the Minamata Convention addressing the continuous emission of mercury vapor into the environment from human activities, the prevalence of mercury in food chain and the demonstrations of harmful effects on humans. The Convention ratifies many responsibilities on the agreed government parties to take a number of actions to eliminate use of mercury in unnecessary products and cut-down its its emission into the atmosphere,

The WHO provides guidelines on substituting mercury-containing thermometers and blood-pressure measuring device. It is going to run projects on proper management and disposal of wastes from health-care centers and develop the use of non-mercury thermometers and sphygmomanometers.

In conclusion, it is found that the commonest sources of mercury are air, soil, rice, fish, medicines, dental amalgam cosmetics and skin-lightening creams. It is because human beings are exposed to these substances more often .The three different forms of mercury: elemental mercury, inorganic mercury and organic mercury are hazardous to human health as evidenced from different studies. They causes toxicities to the nervous system, renal system, cardiovascular system, immune system, reproductive system, endocrine system and so on. Therefore, the Minamata Convention has been signed to promulgate laws against use of mercury and reduce its use in unnecessary products.

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