Examination of Mercury Pollution on Urban Built Environment with Regard Human Health and Emphasis on Drinking Water (Case Study: Drinking Water of Alborz Industrial City)

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Abstract

The quality of water in different usages especially drinking water has an important role on human health. As increasing the urban population and developing the industries, the releasing different materials into water cause various pollutions and problems for human cycles. The important goal of the present study is analyzing the mercury existence and pollution on different part of urban built environment especially drinking water.

Incompatible association between residential areas and other functions have been recently examined and studied. Being adjacent of the residential and industrial areas could generate various pollution, high road traffic, noise, emissions, wastes and wastewaters with heavy metals. For achieving the goal, an important hypothesis was considered, "the existence of industries next to the residential land use, cause to increasing the mercury contents in drinking water". The method of this study was analytic-descriptive and experimental procedure for examining the mercury pollution. Alborz industrial city was the case study. Its drinking water was selected for examining the existence of mercury. The results show that the mercury contents in this area are critical more than WHO guidelines for drinking-water quality. Therefore some important recommendations for decreasing the mercury contents were presented.

Keywords Urban Pollutants, Mercury Pollution, Human Health,Residential and Industrial Areas, Drinking Water.

1. Introduction

As the world's urban population begins to outnumber the rural population, the health effects of urbanization and urban living have recently been studied in greater depth. The physical urban environment has been singled out as one of the many determinants of urban health.

It is well known that environmental pollution is a product of urbanization, technology and other attendant factors of pollution density, industrialization and mechanization that serve to provide the necessities of the population [Mombeshora etal, 1983]. One of the major questions in urban areas is the impact of past, present and future urban development on the water cycle. Heavy metals are easily discharged into an agricultural ecosystem due to common human activities and this result in an adverse impact on the ecosystem. An agricultural ecosystem has a close relationship with human health, thus, heavy metal pollution of agricultural ecosystem has been of concern throughout the world (Bermudez et al., 2011). Heavy metals, as traditional pollutants, are highly toxic, non-degradable and bio accumulative. Mercury as one of toxic and hazardous heavy metal pollution, is a great critical to human ecosystem, therefore it was selected as a sample of heavy metal for studying in Alborz industrial city drinking water. The goal of the present work is examination of mercury pollution on urban built environment with regard human health and emphasis on drinking water, for achieving it, one main hypothesis was considered which the existence of industries next to the residential land use, cause to increasing the existence of mercury in drinking water.

2. Methodology

The Methodology is the general research strategy that outlines the way in which a research project is to be undertaken and, among other things, identifies the methods to be used in it. Having a clear methodology is often deemed important, especially in the sciences. Clearly outlined directions and procedures tend to increase consistency, and to create work which can be repeated elsewhere, which is an important characteristic of rigorous scientific research. In this study, the type of research is application-development and the method is analytic-descriptive and experimental. Method of collecting data is documentation, experimental and studies in the library.

3. Instrument

The measurements were performed with a Perkin Elmer Optima 2100 DV inductively coupled plasma optical emission spectrometry (ICP-AES) (Shelton, USA; www.perkinelmer.com) coupled to a pneumatic nebulizer and equipped with a charge coupled device (CCD).

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4. Theoretical Framework

1. 4.1 Urban Environment

An urban area is a location characterized by high human population density and vast human-built features in comparison to the areas surrounding it. Because of the diversity of cities, and the great contrasts between cities of the less developed and developed worlds it is necessary to consider the impact on health in these cities separately. (Quinn etal, 2011). The quality of urban environments is increasingly recognized to contribute to human health and well-being. The supply and maintenance of health-promoting areas and elements within urban areas such as green spaces are suggested to support residents' possibilities to cope with everyday stress and to have a beneficial effect on human health (Frumkin, 2001;). The continuing urbanization process and pressures on existing green spaces, however, challenge the adequate provision of these areas. In urban planning processes, the health and well-being benefits of nature areas are not fully acknowledged and therefore, their provision is difficult to justify faced with competing land-use interests (Tyrväinen etal 2005).

4.2 Urban pollutants

Urbanization is a process of relative growth in a country's urban population accompanied by an even faster increase in the economic, political, and cultural importance of cities relative to rural areas. The level of air pollution depends on a country's technology and pollution control, particularly in energy production. Using cleaner fossil fuels (such as natural gas and higher-grade coal), burning these fuels more efficiently, and increasing reliance on even cleaner, renewable sources of energy (hydro, solar, geothermal, wind) are some of the best ways to control and reduce air pollution without limiting economic growth.

In the last decades mercury (Hg) levels have been reported in urban atmosphere, urban dust [Liu etal, 2002) and suburban soils and the distribution of Hg in urban soils and the differences of Hg concentration in of land use were determined [Xi et al, 2010]. Mercury level in the air and water are in the range of 2-10 ng/m^3 and 5–100 ng/L (WHO *Guidelines for Drinking-water Quality).* Heavy metals such as mercury may be released in to the environment from metal smelting and refining industries, scrap metal, plastic industries, burning of waste containing these elements and etc [Dale, 1985].

4.3 Mercury effects on human life

Mercury as heavy metal pollution is a toxic and hazardous element and its contamination in water is a global problem because it can cause sensory neural hearing loss, mental deterioration, speech difficulty, impaired vision, vestibular dysfunction and autism (Gopal, 2003). In aquatic environments, mercury is transformed by microorganisms into methyl mercury (MeHg), which bio accumulates and biomagnifies through the food chain, which contributes to high concentrations at the height of an aquatic food chain (WHO, 1990). Indeed, MeHg is recognized as a major environmental contamination issue and health hazard for humans (Qiu, 2013). Owing to its capability to permeate through biological membranes, once MeHg enters the food chain, it is efficiently accumulated and transferred to organisms at higher trophic levels (Mason & Benoit, 2003). As a consequence, the fraction of MeHg from the total Hg (THg) in muscle tissue of top predator fish can be upwards to about 100% (Senn et al., 2010). Worries over the toxicity and human health risk of Hg deposited in ecosystems and bio accumulating as MeHg in food chain such as fish has prompted attempts to regulate anthropogenic emissions of that element (Mergler et al., 2007). The concentration limit for Hg in fish for human consumption is set at 0.5 $\mu g\ g^{-1}$(500 $ng\ g^{-1}$) wet weight, (ww), (CCME, 1999; EEC, 2001; US EPA, 1997;); and 0.2 $\mu g\ g^{-1}$ (200 $ng\ g^{-1}$) (ww) (WHO, 1990) for vulnerable groups, such as pregnant women, individuals under 15 years or frequent fish consumers.

Specifically, large predatory fish which are at the top of the food chain, such as swordfish and tuna, contain high levels of MeHg and are significant sources of human exposure to that contaminant. Public health warnings and guidelines on consumption of fish containing high levels of MeHg have been published by the U.S. Food and Drug Administration (USFDA, 2004) and the European Union (European Union, 2008). However, to this date, official legislation establishing the maximum level of MeHg threshold authorized in seafood for human consumption has not been issued.

4.4 Mercury sources

Mercury is used in a number of products, including electrical and electronic devices, switches (including thermostats) and relays, measuring and control equipment, energy-efficient fluorescent light bulbs, batteries and dental amalgam and laboratory chemicals. Some of important mercury sources are presented in Table 1.

Table 1
Important **mercury sources**

NO	Device	Application
1	Thermometers	Mercury is used in thermometers because it expands and contracts evenly with temperature changes. Alternatives include the electronic (digital) or red alcohol
2	Switches	Shown is the simplest tilt type of mercury switch which conducts electricity and is used in many applications including light switches (silent type), top-loading freezers and washing machines. Some clothing irons have an automatic shut-off switch containing mercury. Irons with mercury-free automatic shut-off switches are available.
3	Thermostats	Mercury in these devices act as switches to energize heating and cooling systems. Electronic versions are available.
4	Thermostat Probes	Thermostat probes or flame sensors consist of a bulb attached to a gas-control valve by a tube containing mercury. They are generally used to prevent gas from flowing when the pilot light of the appliance is off.
5	Luminaries (lights)	Fluorescent HID (High intensity discharge) lamps such as Mercury Vapor, High Pressure Sodium and Metal Halide, and Neon all contain mercury in a metallic as well as vapor form. Mercury is released when bulbs are broken or incinerated.
6	Paints	Latex paint produced before 1992 had large amounts of mercury to prevent fungus growth. Mercury vapors were released when paint was applied. Use latex paint manufactured after 1992.
7	Shoes	- Some shoes with flashing lights in the soles, historically, contained mercury switches.
8	Pesticides	Fungicides and biocides produced before 1994 used mercury to kill fungus, weeds and other pests. Most new pesticides are mercury-free
9	Medical products - Sphygmomanometers (blood pressure gauge)	Contain almost 1.5 pounds of mercury. An aneroid blood pressure unit is a mercury-free option.
10	Medical products - Esophageal dilators.	There is the tapered tip and the blunt tip model. The dilator is two tubes in one. The space between the outer and inner tubes houses the medium, typically mercury. Mercury perfectly fills the need for a heavy, flow able substance capable of dilating the esophagus of a patient in response to medical conditions or treatments that cause esophageal narrowing or tissue shrinkage.
11	Dental amalgam restorative materials (fillings)	Dental amalgam is the end result of mixing approximately equal parts of elemental liquid mercury (43 to 54 percent)
12	Pharmaceuticals	Thimerosal (about 48% mercury) has been used in antiseptic creams and as preservatives in pharmaceutical solutions including contact lens solutions.
13	Plasticizers	Catalyst in Polyurethane manufacturing
14	Soaps/ Cosmetics/Topical Antiseptics	Disinfectant in soaps/Preservative in eye/make-up

(Source: www.ndhealth.gov)

Mercury in products can be released at various points in the product's lifecycle:

- Emissions and wastes generated during the production of the mercury (whether mined, by-product, recycled, etc.) used in the product;
- Emissions during the product manufacturing phase:
- Release through normal product use, as in the case of dental amalgams, cosmetics containing mercury, etc.;
- Release due to breakage during use (e.g., fluorescent lamps and glass thermometers);
- Release due to breakage in the waste stream (e.g., fluorescent lamps) or through dumping;
- Releases during the recycling process;
- Releases associated with treatment and final disposal of mercury waste (whether through burial, incineration or reuse of waste materials (e.g., in cement).

5. Case study

Qazvin province with an area of 15626square kilometers is located in the central of Iran in the range of 48 degrees and 44 minutes- 50 degrees and 53 minutes from Greenwich meridian according to the equator. Qazvin province ranked 26th in terms of breadth among the provinces of the country and according to the last census (1390) has a population of 1,201,565 persons. Alborz industrial city is one of Qazvin province city with an area of 403 square kilometers with population of 88711 persons based on the last General Population and Housing Census (1390) (Statistical Yearbook of Qazvin, 1390).

5.1 Geographical location and communicational roads of Alborz industrial city

Alborz industrial city is located in 15 kilometers of Qazvin (within 140 km Northwest of Tehran), on Qazvin–Tehran transit road, which passes 3.5 km of the city north. Tehran-Qazvin freeway passes 5 km of city north. Tabriz-Tehran railway passes within 3.5 km of the city north, near the transit road. In a near future, a specific railway for the Industrial Zone will be constructed. Two entrance and exit roads, each 45 m wide totaling to 90 m) are connected to Qazvin–Tehran main road.

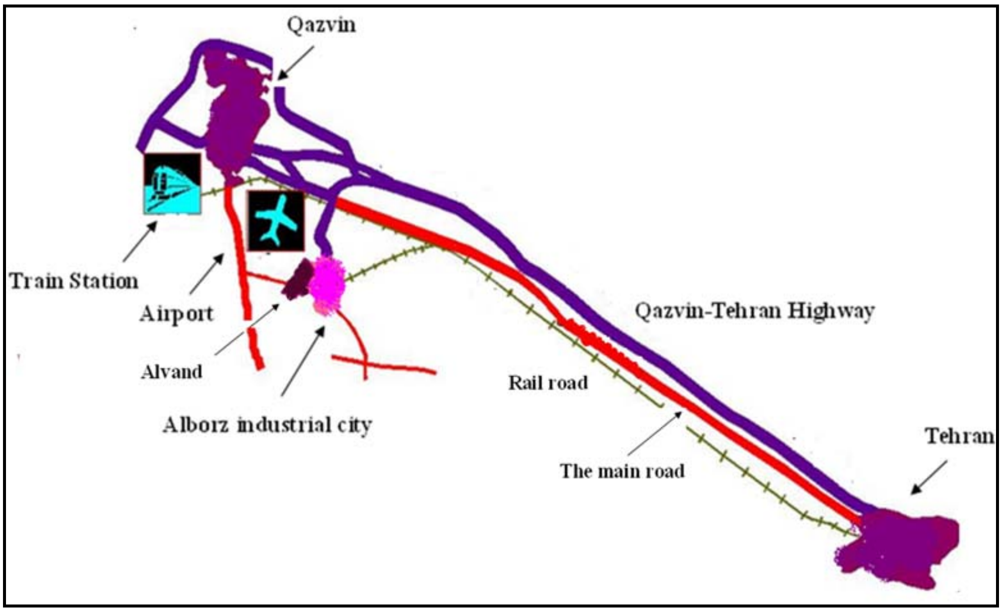

Fig.1 Alborz industrial city

Over half a century after the establishment of the city, is now the largest industrial zone of providing substrates for production and development of industry. It has more than 450 small and big manufacturing units and more than 1000 workshops and services units; therefore it has a significant role in national economy (http://alborzic.ir).

5.2 Facilities and Infrastructures of Alborz industrial city

Alborz industrial city includes three residential, commercial and industrial districts, each provided with appropriate service and public centers.
A) Industrial parts take up 550 hectare. According to the 40-parts Act, each part includes around 450 production units and industrial units of various scales.
B) Commercial parts take up 20 hectares, including 394 workshops/commercial units and over 603 developmental–commercial units.
C) Residential parts take up 80 hectares including 4 districts.
D) Civic public facilities and service and welfare centers take up 230 hectares, including public places, squares, green areas, parks, public service and welfare units.
Civic facilities:
1- The biggest water refinery of the Middle East, whose capacity can be increased up to 90,000 cubic meters
2- Safety unit and fire department
3- Telemetric for online controlling of water flow and the amount of drinking water
4- Customs for importing raw materials and delivering exported goods
5- 16 deep wells, with 15 of which being operated
6- An underground water storage with a capacity of 25000 cubic meter
7- A water tower 2000 cubic meters, 42 m high
8- Gas station
9- 121 hydrant taps distributed all over the city
10- 174 irrigation taps distributed all over the city
11- Chlorine facilities for disinfecting drinking water
12- A 645-kw generator for occasional power outages
13- Guarding and information unit (http://alborzic.ir).
The sampling sites are distributed in heavy traffic density roads, residential and industrial areas of urban areas. The location of sampling sites is given in Fig. 1.
The growth of converted agricultural and industrial areas into built areas, negative externalities, the dynamic of land use changes and the assimilation of peripheral functions within the city are the main consequences for urban landscape vulnerability to incompatible neighborhoods. Most studies are focused on the incompatible association between residential areas and other functions: industrial areas, waste landfills and agricultural areas. Being adjacent of the residential and industrial areas can generate various pollution, high road traffic, noise, emissions, wastes and wastewaters with heavy metals. All these impacts are amplified by the climate area, road network characteristics, and urban agglomeration (Ioan Ioj et al 2012).
Incompatible land-use of being adjacent the industrial and residential areas indicate the trend in territorial planning and generate instability and conflicts leading to degradation in terms of environmental quality. Since, these two different land uses are incompatible land uses in regard of urban planning; they should be located separated from each other. Industrial areas are producing various pollutions which entering heavy metals to the environment are one of them. The majority of chemical pollutants are penetrating to the soil and then entering to the underground water, which finally cause pollutant drinking water. Therefore, industrial areas should be located separated from residential areas. Public transportation such as taxi, bus services and rail road networks should be enhanced for easy attaching of the workers from their home to the industrial areas. Urban landscape structure of Alborz industrial city should be changed, especially due to expansion of residential areas, increasing the risks of a chaotic urban development. The consequences of this residential expansion have led to malfunctions, outlining a disadvantage area due to environmental problems.

6. Real sample analysis

Some drinking water of Alborz industrial city was collected through different parts of the city and the average existence of mercury was determined by inductively coupled plasma atomic emission spectroscopy (ICP-AES). The results are indicated in Table 2.
The World Health Organization (WHO) is a specialized agency of the United Nations (UN) that is concerned with international public health. It was launched in 1948, headquartered in Switzerland. The WHO is a member of the United Nations Development Group (http://www.who.int/en/). The WHO recommends a set of Guideline Values (GVs) representing the concentration of constituents in drinking water that will not result in any significant health risk to a consumer weighing 60 kg over a lifetime consumption of 2 litres per day for 70 years(World Health Organization's Guidelines for Drinking-water Quality 2011).

Table 2
The mean average of mercury in drinking water of alborz industrial city

Sample	Mercury (μg/mL)	WHO 2011 guideline value (μg/mL)
Drinking water of Alborz industrial city	0.082	0.006

As the results show, the existence of mercury in drinking water of alborz industrial city is critical over than the WHO 2011 guideline value which may show the over usages of mercury in industries. Some major recommendations for decreasing the existence of mercury are:

- Locating the industrial areas far from the urban areas.

- Replacing the safe and biodegradable materials instead of mercury in various different industries.
- Purifying the industries and hospital wastes before releasing them into the human environments.
- Developing the safe industrial technologies in various different industries.

7. Conclusion

As urban area is a place for living, therefore human health is directly affected by urban environment. There are several investigations about effective parameters on human health. The great development in industries causes more pollution in urban areas. Urban environmental pollution is changing so researching about their sources is so necessary. Negative externalities, the dynamic of land use changes and the assimilation of peripheral functions within the city are the main consequences for urban landscape vulnerability to incompatible neighborhoods. Incompatible land-use of being adjacent the industrial and residential areas indicate the trend in territorial planning and generate instability and conflicts leading to degradation in terms of environmental quality. The results show that having pollutant and hazardous neighborhood as industrial district for residential area, cause more penetrating pollutant materials such as heavy metals into air, soil and then water. In this study, heavy metals were recognized as one of the most new hazardous and poisonous pollutants and examined their effects on human health and environment. According to the results reported in this study, mercury as heavy metal has capability of diffusion into the ground water resources which is the most important of city drinking water sources. Therefore urban managements should be aware about usage of mercury materials and instruments. Limited usages of mercury could be ordered to the various industries or if it's not possible, the industrial districts should be located far from the residential district.

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