Journal of Multidisciplinary Engineering Science Studies (JMESS)
ISSN: 2458-925X
Vol. 2 Issue 10, October - 2016

Changes in the concentration of BTEX (benzene, toluene, ethylbenzene, m/p-xylene and o-xylene) following environmental and occupational exposure to vapors

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***Abstract*—Nowadays, the prevalence of environmental diseases is increasing worldwide and these diseases are an onerous burden both to the individual and to the public health. Urban air pollution represents a common and difficult problem in the majority of metropolises, which contain high levels of traffic congestion generating great amounts of genotoxic substances. Volatile organic compounds (VOCs) play an important role in ecological damages, disturbing the ecosystem and human health. Although the association between COPD and urban air pollution is well established, the relationship between the concentration of BTEX (benzene, toluene, ethyl benzene, isomeric xylenes) and occupational and environment risk factors has not been investigated. The objectivities and methods of our study were to determine the concentration of BTEX in urine in inhabitants from urban and rural areas, as well as in workers in shipyard, who are occupationally exposed to volatile aromatic hydrocarbons. Results: people living in urban industrial fields have significantly augmented the concentration of BTEX in urine, as well as the occupationally exposed workers in shipyards.**
Conclusion: BTEX-analyze in urine, as an important and easy method represents a good marker in environmental monitoring which contributes better protection of air pollutants and quicker diagnosis of occupationally exposed individuals.

Keywords—biomonitoring, BTEX, environmental diseases, occupational exposure, vapors

Introduction

Factors that lead to the pathogenesis and development of environmental diseases are not yet well known. Environmental diseases, by definition of the World Health Organization (WHO) are primarily caused by air and water pollution, chemical and physical agents, radiation, contaminated food and direct contact with the toxins which are exposed to natural and/or working environment and their incidence is increased in last decades in the developed western countries. Nowadays, many of them (asthma, allergic rhinitis, chronic obstructive pulmonary disease) are a major public health problem, and it is necessary to recognize environmental toxins and determine their mechanisms of action in order to achieve the best preventive and therapeutic effects. The concept of environmental diseases has gained an enviable status in the modern scientific research; because it is proven that the increased concentrations of toxic and carcinogenic pollutants in the environment proximately cause an increased incidence of various cancers and severe forms of the environmental diseases (COPD, asthma). Various toxic substances released into the environment every day leading to the increased incidence of diseases in humans and disorders in biological balance and change the quality of life. Many of these substances have very strong toxic effects, slowly dissolve in water and remain very long in the environment, cause the long exposure to them. Toxic substances may act on living organisms immediately if the surface (epithelium) is damaged and enter the internal organs, and indirectly when operating in environmental conditions (changing the environmental factors). Biological accumulation of some toxic substances in the human body depends on a number of properties of the pollutants (chemical structure, stability, interactions of different substances) and the characteristics of the organism (physiological, biochemical, genetic, health, and nutritional status). On the biological accumulation of some toxic substances, except the specificity of the organism and contaminants, affect also operating and environmental conditions such as temperature, humidity, UV and other factors. Aromatic hydrocarbons such as benzene, toluene, ethylbenzene, m/p-xylene and o-xylene (BTEX), are excreted from the body partly in unchanged form via the exhaled air, but mainly as metabolites in the urine via the kidneys where it is less 1% of unchanged [1]. Through exhaled air small amount of these compounds coming from the body, and the best indicator of removal of the biological half-life, which varies depending on the type of tissue: less than 5 minutes for blood; a few minutes to a few hours for muscles and a few hours to several days of adipose tissue [2]. Volatile aromatic hydrocarbons (BTEX) are compounds that are released into the environment through the exhaust of cars, the work of many industrial plants and the burning of municipal waste. The most dangerous to human health is benzene, which is as far back as 1982, the

IARC agency (International Agency for Research on Cancer) classified it as human carcinogen. Many studies have demonstrated a very toxic and genotoxic effects of benzene in relation to human health. In studies dealing with the study of toxic effects of BTEX on human health, it is determined in blood and urine. The concentration of BTEX in the human body is exactly proportional to the proximity of housing people in relation to the main roads and industrial plants [3].

The concentration of BTEX in urban areas with developed urban traffic, near operating oil refinery is significantly higher than concentrations in rural areas [4]. Most of the research carried out during the winter months, because it is a whole range of environmental factors (lower photochemical decomposition, high humidity, low temperature) which are closely linked to increased concentration and longer endurance BTEX in the environment, and consequently their greater biological accumulation in the human body [5-7]. The exposure of the above compounds is associated with an increased risk for human health [8]. They are first of all detected compounds commonly found in an urban air, and are associated with a development of various environmental diseases [9, 10]. Exposure to benzene is often associated with an increased incidence of development of leukemia and solid tumors [11], and many scientific studies have suggested a link between the development of the environmental diseases and urban housing [12-14]. Moreover, exposure to toluene and xylene leads to toxic effects on the nervous system, liver and kidneys, as a target organ of said contaminants that are found in greater concentration in the air in urban areas [15, 16]. Environmental exposure to ethylbenzene, in inhabitants living and working on traffic and industry burdened area, causing serious health problems to the respiratory system and the kidneys [17]. The studies that have been conducted in humans have shown a close link between environmental exposure to various pollutants and certain diseases or health problems. To understand the etiology of the disease association with environmental changes, these studies have demonstrated connection between the discharge of pollutants into the environment with the development of many diseases or damage to the health of individuals or entire communities [18]. BTEX can enter into the body through the skin and the digestive system, or by the inhalation of the most common route of entry [19]. Inhalation of BTEX-contaminated urban air in humans' leads to the development of COPD, which is a characteristic environmental disease represented in this population of subjects compared to the population from rural areas [20-22]. The development of new analytical techniques, recommended the determination of volatile aromatic hydrocarbons in urine, due to the simplicity of sample collection and the very high precision measurements. The incidences of the environmental disease rapidly increased in developed countries and pose a major risk to the individual and the community health. These are precisely the reasons why the environmental diseases need to be recognized and the factors that promote their development should try to eliminate or reduce their toxic effects [28, 29]. Many toxic compounds, primarily volatile aromatic hydrocarbons such as BTEX, are released into the environment through the exhaust of cars and operation of industrial plants as inevitable by-products of combustion of various petroleum fractions. Many studies have demonstrated a very toxic, carcinogenic and genotoxic effect of benzene in relation to human health. Concentrations of BTEX introduced in the human body are precisely proportional to the proximity of housing people in relation to the main roads and industrial plants, thus living in large urban areas is a potential risk of exposure to increasing concentrations of the above compounds for high intensity traffic and uninterrupted operation of many industrial plants that are recognized as main source in an integrated environment. Determination of the concentration of BTEX in human urine reflects the overall objective and the exposure of these compounds in the environment, because the compounds of the same name cannot arise metabolic pathways in the body itself [30].

The aim of the study

The objectives of this study were to examine the release of BTEX in urine in inhabitants from urban and rural area, as well as in occupationally exposed individuals (workers on marine construction at the shipyard „Kraljevica"as well as workers of shipyard Viktor Lenac which is situated in urban industrial area). City Rijeka, which is situated in Adriatic Sea is an example of urban area, while island Mali Losin is rural area.

Subjects and methods

In this experiment we included a group of subjects of Rijeka (n = 35) who lives and works in a typical metropolitan area (urban area), the group of respondents who live and work on the island of Mali Lošinj (n = 35) as characteristic of unpolluted areas (rural) and occupationally exposed subjects who worked on marine construction in the shipyard "Viktor Lenac" (n = 35), situated in industrial area, and the same group of respondents who work on marine construction at the shipyard "Kraljevica" (n = 28). Occupationally exposed groups of participants were daily coating of marine construction (shipbuilding) and are exposed to volatile aromatic hydrocarbons benzene, toluene, ethylbenzene and xylene isomers through inhalation and contact, using paints, varnishes, solvents, thinners and biocidal products which have volatile aromatic hydrocarbons as organic solvent. BTEX were analyzed from urine by a HS-SPME method, which is similar as described Karaconji B and coauthors [31]. All samples were obtained in accordance with the published International Health Guidelines (declaration of Helsinki "Ethical principled for medical research involving human subjects"). All experiments have been approved by a local ethics committee. For statistical analysis we used a personal computer and software package Statistica 12 (Stat.Soft, Inc., Tulsa, OK). Of the non-parametric tests we used the Mann-Whitney test for two independent groups of samples, or the Kruskal-Wallis test for multiple samples. Sample size was determined the required strength test and the level of statistical significance. In our research, we use the normal force test in biomedicine and 80% significance level of the usual 5% ($P < 0.05$).

Results

We have examined and analyzed the changes of BTEX in the urine of workers of the shipyard Viktor Lenac and

Kraljevica, and residents of urban areas of the city of Rijeka and the rural areas of the town. Pictures 1-5 have shown the differences in the concentration of BTEX in urine in our test group. The highest concentrations of BTEX were found in workers from shipyard Kraljevica. Figure 6 summaries the concentration of BTEX in all examine groups. Statistically significant increase of BTEX concentration was found in urine of all workers who are occupationally exposed to volatile aromatic hydrocarbons. The similar significant increase are present between urban and rural areas, where rural areas have significant decreased in BTEX concentration.

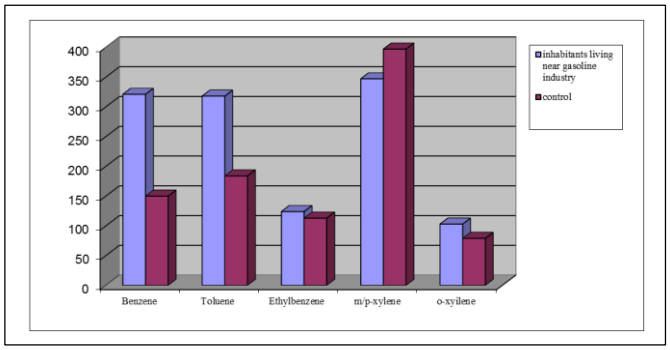

Fig. 1. BTEX concentration in urban and rural area

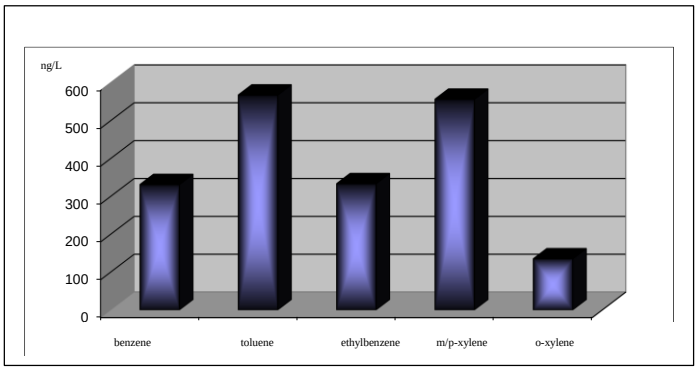

Fig. 2. BTEX concentration in shipyard „Viktor Lenac"

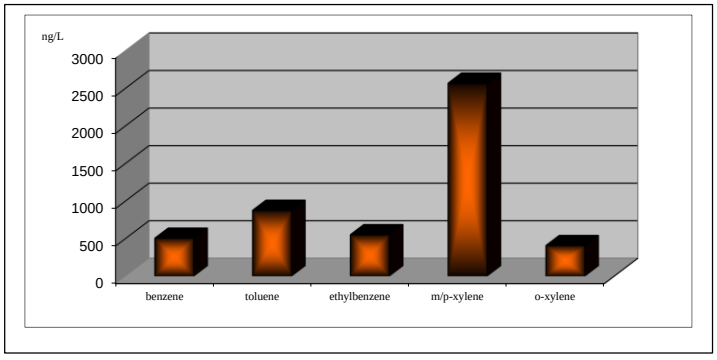

Fig. 3. BTEX concentration in shipyard „Kraljevica"

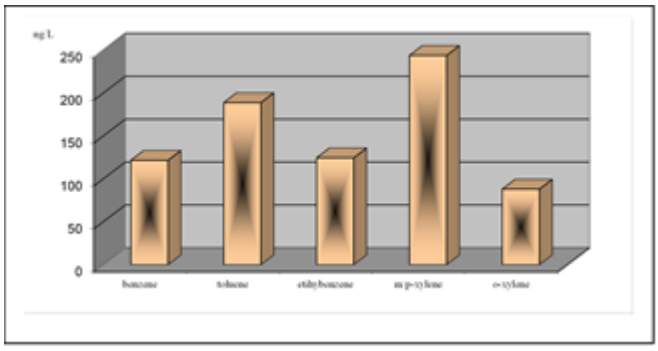

Fig. 4. BTEX concentration in city Rijeka (urban area)

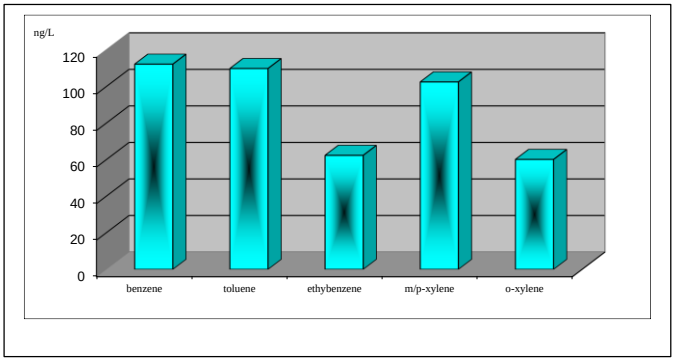

Fig. 5. BTEX concentration in the island Mali Losinj (rural area)

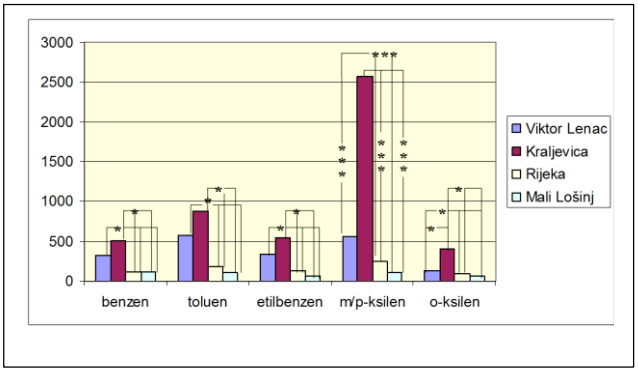

Figure 6. Summary result for the average values of the concentration of BTEX in urine in all investigated groups

Discussion

In modern scientific research of the last decade due to the aforementioned characteristics of volatile aromatic hydrocarbons, and very easy entry into the human body, the most attention was the clarification of the damaging effects of BTEX on human health. The toxic effects of BTEX not equally for all compounds studied, the highest data collected for benzene due to his hematotoxicity and carcinogenicity, followed by toluene because of their neurotoxicity, while the xylene isomers and ethylbenzene sparse data. All these compounds as organic solvents have a local effect on the skin and mucous membranes, and after

absorption, the systematic effect is manifested in the central nervous system. Benzene has very strong haematotoxic effects with reduction the number of blood cells, induces also bone marrow hypoplasia, pancytopenia, myeloid leukemia and a very strong inhibition of incorporation of iron in red blood cells which is particularly damaging during early development of the human body [32, 33]. Occupational exposure of humans to benzene is very dangerous to health. It has been proven that occupational exposure to benzene can lead to chromosomal aberrations, sister chromatid exchange, micronuclei and the occurrence of inhibition of synthesis of DNA and RNA molecules since benzene and its metabolites form DNA adducts. Neurotoxic effects of toluene and xylene in humans are caused by their presence in the phospholipid cell membranes of the nerve and disruption of its essential role (excitability in the creation of an action potential) and the presence of toluene and xylene in the myelin of nerve fibers, which can disrupt their role in the conduction of electrical impulses. Symptoms of neurotoxic effects in humans is manifested as severe headache, dizziness, drowsiness and sometimes loss of consciousness, which can result in acute poisoning if the residence time in this work environment is not curtailed to a minimum [34, 35] . For ethylbenzene, the data are very poor, but there are studies that prove its acute and chronic toxicity of the central nervous system which may manifest in the form of severe headaches, insomnia, irritability and fatigue. Urban air pollutants are known to contribute to increased prevalence of environmental diseases and multiple toxic chemical sensitivity or other related syndromes, as a result of an abnormal immune response based on environmental damage of lymphocyte subsets. Besides the characteristics of the human organism (physiological, biochemical, genetic), and chemical characteristics of potentially hazardous pollutants (solubility, volatility), many other environmental factors affect the incidence of the environmental diseases. Factors such as temperature, humidity and light intensity, have a major impact on the biological processes of accumulation and bioavailability of contaminants in the body. Bioavailability is the degree to which pollutant is free to enter into the body and potentially produce effects at the site of action, and these places are the site of entry (locally), output area (systematic), and a place of secretion (skin, visible mucous membranes). Toxic environmental factors which have a possibility to induce immunological changes may contribute to develop environmental diseases [36-38].

. Between all of these environmental factors, the concentration of pollutants in the environment itself however is a key reason for appearance of certain diseases of the environment. Volatile aromatic hydrocarbons benzene, toluene, ethylbenzene, o-xylene and m/p-xylene have been proven in higher concentrations in those areas with developed oil industry and increased traffic frequency. Our results have showed that the concentrations of BTEX in urine are increased in shipyard workers in relation to residents of urban areas (Rijeka), and in particular the major changes compared with the inhabitants of rural areas (Mali Lošinj). People from industrial area have significantly increased BTEX (benzene, toluene) in urine.

Conclusion: BTEX-analyze in urine, as an important and easy method represents a good marker in environmental monitoring which contributes better protection of air pollutants and quicker diagnosis of COPD and asthma.

Acknowledgement: This work was supported by grants from University of Rijeka (13.06.1.1.14 and 13.06.1.1.15).

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