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Review Article

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A REVIEW ON EFFECTS OF SOME GASES EMITTED FROM MUNICIPAL SOLID WASTE LANDFILLS ON HUMAN REPRODUCTIVE SYSTEM

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ABSTRACT:

Everyday millions tons of different gases are emitted into the atmosphere from municipal solid waste landfills (MSWL). Several of these gases are toxic, carcinogen or mutagen. Therefore, it is important to have information about health effects of MSWL gases. Some of MSWL gases have negative effects on human reproductive system. The aim of this article was to collect short information about negative effects of some gases emitted from MSWL on human reproductive system.

This study was carried out in two steps. First, recognizing the gases emitted from MSWL using an extensive literature review and second, finding their intensity of negative effects on human reproductive system.

The major part of gases emitted from MSWL is methane and carbon dioxide. Both of these gases are not known as a toxic compound for human reproductive system. Many compounds that have been categorized as non - methane organic compounds such as 1, 1, 1- trichloroethane, 1, 1, 2, 2-tetrachloroethane, 1, 1- dichloroethylene, 1, 2- dichloroethane1, 2- dichloropropane, acrylonitrile, benzene and acetone are toxic for human reproductive system.

The most important method to prevent the negative effects of gases emitted from municipal solid waste landfills is combusting of them to recover their energy.

REVIEW

Nowadays, millions tons of municipal solid waste are producing worldwide that must be sanitarily disposed [1]. Various processes including composting, incineration, pyrolysis etc., have been suggested to dispose solid waste which each one has advantages and disadvantages [2]. Among of different methods to dispose municipal solid waste, sanitary landfill is the most common method [3]. The municipal solid waste contains a

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large amount of organic and biodegradable compounds. Therefore, after landfilling solid waste its organic part is degraded by microorganisms [4]. Since a few amount of air is trapped among of landfilled solid wastes, the organic compounds are aerobically degraded by microorganisms ,5] 6]. In aerobic degradation organic compounds are converted to water and carbon dioxide [7]. The trapped air among of solid wastes are gradually reduced and anaerobic degradation is started [8]. The anaerobic microorganisms use organic compounds and convert them to carbon dioxide, methane, water, hydrogen sulfide, ammonium and hundreds of non - methane organic compounds [9]. These gaseous compounds known as landfill gas are emitted into the atmosphere from solid waste landfills.

The amount of landfill gas released into the atmosphere in large cities is huge and can spread up to miles around the landfill. It is reported that in the years between 1997 and 2029, the amount of carbon dioxide, methane and non - methane organic compounds released into the atmosphere from the landfill site of Shiraz would be equal to 756900, 2077000000 and 325000000 tons [1]. These results showed that the amount of gases produced is very high, so it is possible to create a danger to human health. Usually, methane and carbon dioxide are the highest in all of the gases emitted in landfills [10]. The smallest part of landfill gas is related to non - methane organic compound. Although the amount of non - methane organic compounds is small, the importance of them is very high. For example, vinyl chloride and benzene are carcinogenic compounds released from municipal landfills into the atmosphere. Many other non - methane organic compounds also have teratogenic and mutagenic effects.

Mutagenic is an alteration on DNA sequences which causes permanent changes to genetic material capable of transfer to next generation. Some chemical substances called teratogen cause birth defects via a toxic effect on an embryo or fetes. A reproductive toxin is a substance which interferes in any way with the reproductive process. Such compounds can seriously threaten the health of urban landfill workers and even residents of areas near landfills. It is reported that the concentration of non - methane organic compounds at a distance of 2400 and 500 m from the Jahrom landfill site and in the wind direction was about 0.032 and 0.35 $\mu g / m^3$ [2]. The most important gases released from landfills are shown in Table 1 11])].

An inexpensive way to control methane emission in the landfills could be collection of the biogas and converting its methane to carbon dioxide by using a gas burner. Most of the dangerous non - methane organic compounds in the flares are burned and converted to harmless compounds. Since landfill gas contains a lot of methane and this gas has a lot of chemical energy, it can be used to generate electricity [12]. By burning the landfill gas in an electrical generator engine, not only can control the release of hazardous pollutants but also there is the possibility of generating revenue from the sale of electricity. Each kiloowatt of electricity produced from Landfil gas was purchased as much as $ 0.08 for supporting the production of renewable energy and reducing pollutant emissions to the atmosphere by the Ministry of Energy in Iran purchases. It was reported that the landfill site of Jahrom could produce 8000 MW of energy only in 2016 [2]. Since several gasses released from landfills are dangerous for human health, recognizing their effects on human health is of great importance. Therefore, the purpose of this study was to introduce the most important gases released from landfill and review their effects on human health.

Table 1. The most important gases released from landfills [1, 2, 5, 7, 8, 9, 11]

Pollutant	Pollutant	Pollutant
Pentane	Dichlorofluoromethane	Toluene - No or Unknown Co-disposal
Perchloroethylene (tetrachloroethylene)	Dichloromethane (methylene chloride)	Toluene - Co-disposal
Propane	Dimethyl sulfide (methyl sulfide)	Trichloroethylene (trichloroethene)
T - 1, 2 - Dichloroethene	Ethane	Vinyl chloride
1,1,1 - Trichloroethane (methyl chloroform)	Ethanol	Xylenes
1, 1 ,2 , 2 - Tetrachloroethane	Ethyl mercaptan (ethanethiol)	Dichlorobenzene
1, 1 – Dichloroethane (ethylidene dichloride)	Ethylbenzene	Dichlorodifluoromethane
1, 1 – Dichloroethene (vinylidene chloride)	Ethylene dibromide	Carbon tetrachloride
1, 2 - Dichloroethane (ethylene dichloride)	Fluorotrichloromethane	Carbonyl sulfide
1,2 – Dichloropropane (propylene dichloride)	Hexane	Chlorobenzene
2 – Propanol (isopropyl alcohol)	Hydrogen sulfide	Chlorodifluoromethane
Acetone	Mercury (total)	Chloroethane (ethyl chloride)
Acrylonitrile	Methyl ethyl ketone	Chloroform
Benzene - No or Unknown Co-disposal	Methyl isobutyl ketone	Chloromethane
Benzene - Co-disposal	Methyl mercaptan	Carbon monoxide
Bromodichloromethane	Butane	Carbon disulfide
Methane	Carbon dioxide	-

Methane and carbon dioxide

Methane with chemical formula CH_4 is the most important gas emitted from municipal solid waste landfills. Methane is simplest compound in Alkanes group and the main consist of natural gas. Abundance of methane makes it an attractive fuel for usage in houses, industries or even vehicles. The major part of organic compounds in municipal solid wastes can be converted to the methane by activity of anaerobic microorganisms in the landfills. Methane has several adverse effects on the human health. Methane is not considered as a mutagenic compound for human. Also, no embryo toxic effects have been described for it. Methane is not known as a toxic compound for human reproductive system. Carbon dioxide is another important chemical that are produced in solid waste landfills. It is known as a major reason of global warming. It was reported that carbon dioxide is not expected to cause mutagenic, embryo toxic, teratogenic and adverse reproductive effects in humans. Although the major part of landfill gases (methane and carbon dioxide) do not have an adverse effect on reproductive system on humans, other part of landfill gases such as non-methane organic compounds have a significant effect on it.

1,1,1- Trichloroethane

1, 1, 1- Trichloroethane with chemical formula C_4H_5N is one of the non - methane organic compounds that are released from landfills [13]. 1, 1, 1-Trichloroethane is considered as a suspected toxicant for human reproductive system [14]. This compound is a common solvent to degrease metals surface; therefore, it has a wide applications in the industries. Since 1,1,1-trichloroethane has an negative effect on ozone layer, its usage has been limited in several parts of world. A little amount of 1, 1, 1- trichloroethane has been emitted from municipal solid waste into the atmosphere. It has adverse effects on human health that can be influenced by many factors such as individual sensitivity to the chemical, sex and level of exposure. The exposure with 1, 1, 1- trichloroethane cause many problems for females reproductive system like infertility, menstrual problems, altered puberty onset, altered sexual behavior, changing length of pregnancy, lactation problems, altered menopause onset and pregnancy outcome. 1, 1, 1- trichloroethane has some negative effects on males reproductive system including changing sexual behaviors, infertility, reduce the sperm count or problems with sperm shape. DHSS (2004) reported that the male rats and mice that exposed whit 1, 1, 2, 2- tetrachloroethane had reduced left cauda epididymis, left epididymis, and left testis (mice) weights and epididymal spermatozoal motility compared with the vehicle controls [13]. Also, under concentration of 2300 ppm female rats had longer diestrus and shorter proestrus, estrus, and metestrus than did vehicle control females. In the concentration of 9,100 ppm the estrous cycle of female mice was longer than that of the vehicle controls [13].

1, 1, 2, 2- Tetrachloroethane

The review of literatures showed that there a little information on the reproductive or developmental toxicity of 1, 1, 2, 2 - tetrachloroethane in humans. The results of experiments on animal cases showed that 1, 1, 2, 2 - tetrachloroethane do not have significant effects on animals. A study on the female rats showed the numbers of litters or pups did not change when they exposed to air contaminated with 2 ppm of 1, 1, 2, 2- tetrachloroethane for 325 days [15]. Existence of 400 to 700 mg / kg of 1, 1, 2, 2 - tetrachloroethane in the diet of pregnant mice showed that this chemical were not embryotoxic. Based on this limited data,

the researchers could not conclude whether this substance is embryotoxic.

1, 1- Dichloroethylene and 1, 2- Dichloroethane

1, 1- Dichloroethylene is considered as a toxicant for human reproductive system. This compound is used for production of plastics and silicon dioxide films. The negative effects of 1, 1 -dichloroethylene depend on different factors including personal sensitivity to the chemical, level of exposure and sex. Several symptoms can be appeared when females are exposed with 1, 1 -dichloroethylene including altered menopause onset and pregnancy outcome, infertility, altered sexual behavior, menstrual problems, altered length of pregnancy and lactation problems. This compound can have some negative effects on male reproductive system such as changing the shape or number of sperms, changing sexual behaviors and reducing reproductive ability.

A number of professional medical advices are found in the literatures to reduce the symptoms of 1, 1 - dichloroethylene exposure on human reproductive system including avoiding 1, 1-dichloroethylene exposure with different strategies such as legislation to ban teratogenic compounds, suitable workplace strategies to reduce exposure for workers at risk and public education for the people and pregnant mothers.

It was reported that inhalation exposure to 1, 2 - dichloroethane with concentration more than 0.4 ppm can increase the number of premature births in female workers. Premature births can be also happened for wives of male workers who were exposed to 1, 2 - dichloroethane [16]. The results of this study must be treated with caution due to small number of subjects (44 male and 54 female exposed workers) that were evaluated. Some researches that were carried out on rodents showed that [16 - 18] inhalation exposure to 1, 2 - dichloroethane either prior to mating and continuing into gestation or throughout gestation caused pre - implantation loss and embryolethality, although the reliability of these studies is unclear because of deficiencies in reporting study design and results.

1, 2- Dichloropropane

There are few reports about negative effects of 1, 2 - dichloropropane on human reproductive system [19]. For example it was reported that a woman was hospitalized due to bleeding from the uterus between menstrual periods (metrorrhagia) after acute exposure to 1, 2 - dichloropropane [20]. The reported metrorrhagia was a transient effect. The concentration of inhaled 1, 2-dichloropropane was not reported. Any histological changes were not reported for rats that exposed to 1000 ppm of 1, 2 - dichloropropane [21]. Same results were reported for mice exposed to 300 ppm of 1, 2 - dichloropropane for 2 weeks (6 h / day, 4 to 5 days / week) [21]. “No histological changes in the epididymis, prostate, or testes of males and in the oviduct, uterus, cervix, ovaries, or mammary glands of females were observed in rats and mice exposed to ≤ 150 ppm and in rabbits exposed to ≤ 1000 ppm 1, 2 - dichloropropane for 13 weeks (6 h / day, 5 days / week)” [22].

Acrylonitrile

Low amount of acrylonitrile are emitted to the atmosphere from landfills. It was reported that acrylonitrile is a suspected reproductive toxicant [23]. Exposure to acrylonitrile has the potential to adverse effects on human reproductive system. The main usage of acrylonitrile is to produce acrylic that is a basic compound for making plastics, coatings, dyes, adhesives and pharmaceuticals. The intensity of negative effects of acrylonitrile depends on some factors including sex, personal sensitivity to the chemical and level of exposure. Exposure to acrylonitrile can

face females to many problems like: (a) changing sexual behavior; (b) menstrual problems; (c) reduce the infertility ability; (d) altered puberty onset; (e) changing menopause onset; (f) changing pregnancy length; (g) and lactation problems [23]. High level of exposure to acrylonitrile in the drinking water shows birth defects in animals. Animals that were exposed to acrylonitrile had different birth defects for three generations [24]. There is no any report to proof that acrylonitrile has permanent birth defects on human reproductive system. No studies were done regarding reproductive effects in humans or animals following inhalation exposure to acrylonitrile.

Benzene and acetone

Benzene is known as strong reproductive toxicant. Exposure to this compound can have negative effects on human reproductive system. Benzene has a wide usage in many industries such as paper and pulp manufacture, printing, pesticide manufacturing, laboratory chemicals and pharmaceuticals manufacture. Also, it can be emitted from municipal solid waste landfills. The intensity of negative effects of benzene on human reproductive system can be influenced by factors including personal sensitivity to the chemical and level of exposure [25]. Benzene has several negative effects on male infertility system such as changing sexual behavior, reducing number of sperms and changing the shape of sperms.

Only little information is found on negative effects of acetone on human reproductive system. Exposure to acetone can reduce the number of sperms in males [26]. Also, number of adverse effects of acetone on female reproductive system of animals has been recognized.

CONCLUSIONS

Tens different gases are emitted from municipal solid waste landfills into the atmosphere that several of them have negative effects on human reproductive system. Methane and carbon dioxide are the major part of gasses emitted from municipal solid waste landfills. Both methane and carbon dioxide are not known as a toxic compound for human reproductive system. Many compounds that have been categorized as non- methane organic compounds such as 1, 1 ,1 - trichloroethane, 1, 1, 2, 2 - tetrachloroethane, 1, 1 - dichloroethylene, 1, 2 - dichloroethane1, 2 - dichloropropane, acrylonitrile, benzene and acetone are toxic for human reproductive system. It is recommended to avoid negative effects of gases emitted from municipal solid waste landfills on the human health; they should be collected and burned.

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COMPETING INTERESTS

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

AUTHOR'S CONTRIBUTIONS

It is certified that all of the authors have made the same contribution in the experiments and manuscript writing.

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ETHICAL CONSIDERATIONS

Authors are aware of, and have complied with, best practices in ethics, specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on

research ethics. Authors adhere to publication requirements that the submitted work is original and has not been published elsewhere in any language.

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