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Short Review on Xenobiotics and Human Health

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Abstract

Xenobiotics are the agents which are foreign to the human body or the biological system. They are known to induce metabolic disorders in the human body, carcinogenesis and cause environmental pollution. Xenobiotics fall under various categories based on their source like the industrial xenobiotics and the food xenobiotics. They act as endocrine disruptors by blocking activity of hormones, disturbing hormonal transportation in the body or interfere in their synthesis. Hence it is very important to raise public awareness on the xenobiotics and their sources and impose strict regulatory guidelines on xenobiotics. This article covers the various aspects of xenobiotics, their health concerns and suggests some remedial measures.

Keywords

Xenobiotics, human health, endocrine disruptors, hormones, industrial waste, pesticides.

Introduction

In recent era, the rise in certain metabolic disorders like obesity, hepatic diseases, type 2 diabetes, PCOS and the metabolic syndrome has been observed worldwide. The root cause behind this drastic shoot up in degenerative diseases has been attributed to some kind of endocrine disrupting chemical compounds also known as xenobiotics as they are known to derange metabolic control of the body.

The xenobiotic induced cell damage and mutations are a significant risk to the health of the living organism as they lead to the malignancy and also cause various heart diseases. Their presence is everywhere, including the food items as colorants, stabilizers, flavouring agents, preservatives, air conditioners, dust, oil paints etc. They can manifest various health conditions like nasal congestion, allergies, chest heaviness, shallow breathing etc. which can lead to other severe health conditions (Kucherenko *et al*., 2021).

Through this review the author has tried to analyse the various health impact caused due to the presence of xenobiotic.

What are xenobiotics?

Xenobiotics are foreign compounds or manmade substances that are neither a part of body nor these are part of nature. Natural compounds may act as xenobiotics in specific conditions, e.g. if they are ingested by another organism or in the form of chemical defence materialise e.g., mycotoxins, herbal or bacterial toxins etc. that are produced by the prey for protection from predators (Brodie *et al*., 2002).

Xenobiotics are many times referred to pollutants also like dioxins and polychlorinated biphenyls and their impact on the living organisms as these are entirely foreign substances to a biological system, i.e. these are artificial compounds, which are manmade, not natural

(Wikipedia). Xenobiotics are gaining public interest and these are evolved by various human activities only.

Xenobiotics are considered very harmful when these involve in the food chain. Human exposure to xenobiotics can't be escaped as these are present everywhere. Some xenobiotics are ingested voluntary in the form of medicines; e.g. antibiotics, and dietary supplements etc. (Soucek, 2017).

Different categories or sources of xenobiotics

Industrial xenobiotics: Industrial xenobiotic substances are a major concern for sewage treatment systems because of their huge amount & each one of them needs separate mode of clearance. Some xenobiotic substances are resistant to degradation, e.g. trichloroethylene (TCE), polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). These are major cause of environmental pollution. Many other industries also cause environmental pollution from xenobiotics like, pharmaceuticals, fuels yielded from fossils, pulp or paper bleaching and agriculture industry (Singleton, 1994).

Other types of xenobiotics are paint, adhesives, doxins, polychlorinated biphenols, plastic in the form of synthetic organochlorides, polycyclic aromatic hydrocarbons (PAHs) and in the form of some part of crude oil and coal.

Food xenobiotics: A variety of products including pesticides and insecticides pose high risk to human from food, water and environment. The major concern is health risk imposed from food borne toxins, preservative andartificial sweeteners (Michael, 2015). Artificial sweeteners, which are ingested by consuming "diet" recipes may also affect hormonal control of energy metabolism and thus can be termed as endocrine disruptors.

Smith Spangler *et al*., (2012) reported a high concentration of polyphenols, phosphates and n-3 fatty acid in organic food products As per Morris (1983) xenobiotics can be incorporated in food stuffs by many ways. Some of which are added food or colour additives or from food packaging material. At the time of crop growth and maturation or harvesting, environmental pollutants may become part of food. Effect of food derived xenobiotics was studied by Nogacka *et al*. (2019). Meat and fish foods derived xenobiotic compounds like nitrosamine, heterocyclic amines and polycyclic aromatic hydrocarbons that are produced due to some cooking procedures at high temperature are known to induce carcinogenesis.

How xenobiotics affect human body?

Environmental chemicals can behave as endocrine disruptors by blocking activity of hormones, disturbing hormonal transportation in the body or interfere in their synthesis (Michael, 2015). These may also block receptor sites for hormone binding that may influence gene expression or may incorporate epigenetic alterations in the host. These compounds affect endocrine or metabolic system of the body when they enter through ingestion or inhalation or enter in blood circulation by any other manner. Some of these compound different biochemical activities that drastically imbalance endocrine functions that may lead to infertility or diabetes. Xenobiotics present in industrial waste can interfere hormone functioning that is necessary for normal reproductive function.

Other endocrine disruptors like PCB and PBDE have been shown to inhibit binding of thyroid hormone to trans thyretin, potentially affecting thyroid hormone function.

Environmental radiations may affect thyroid gland function and can lead to thyroid cancer also. Many xenobiotic compounds are lipophilic that are not excreted out of body & accumulate in body for life time. Moreover, environmental polychlorobiphenyls and perfluoro alkyl compounds are global environmental contaminants. These may lead to fatal health consequences of pulmonary tuberculosis, pulmonary fibrosis and asthma that is a common health issue of coal workers or labour who is exposed to asbestos. Nanomaterials are also documented as toxic environmental xenobiotics that are generally a component of vaccines or medicines. Xenobiotics like drugs, food additives, pollutants and agriculture chemical products may also influence gut microbiome in gastrointestinal tract that is a major cause of non-alcoholic liver disease (Ramaka *et al*., 2020).

In the form of pesticides, organo chlorinated compounds (OCPs) maybe accumulated in human body through enterohepatic reabsorption and affinity to adipose tissues and that's why these are not entirely excreted out from our body. One of the important examples of this type of pesticide is pyrethroid (Zhu, 2017). As per Singh (2004) also recalcitrant properties of pollutants are responsible for their accumulation in the environment and this is a major cause of concern for human healthdue to their toxicity. Anticancer drugs e.g. cisplatin and commonly used other drugs like digoxin, phenytoin and carbamazepine may also act as xenobiotic by producing nephro toxicity (Ramaka *et al*., 2020).

Xenobiotics can affect human body by altering from their normal metabolism process that makes them more toxic. This phenomenon is termed as bio activation that can result in anatomical & physiological changes to the microbiota (Mansuy, 2013). In another study, Park *et al*. (2011) mentioned that physiological changes in the microbiota depend on the substance and may be presented in the form of altered gene expression in stress state, antibiotic resistance, disturbed levels of metabolites etc.

Organisms can also develop xenobiotics resistance as found in the study of Brodie *et al*. (2002), Geffeney *et al*. (2002) and Broehan *et al*. (2013). Xenobiotics metabolism is affected by many other factors also. One of the major factors is age. It occurs differently in different age groups. Newborns are more vulnerable to endocrine disruptors as they lack enzymes required for oxidative metabolism. The metabolism of xenobiotics depends on the dose, dilution, route, dissemination to different parts of body and the protein binding site. Pharmaceuticals and other xenobiotics compete for the active centres of enzymes, which reduces the metabolism. Finally, toxic compounds (pesticides, carbon monoxide) may affect the enzymatic activity and reduce the metabolism (Kucherenko, 2021).

Many of these compounds are lipophilic and without clearance mechanism. They accumulate in the body throughout the life time of individual and passed on from mother to offspring. In a research by Hatch *et al*. (2008) an association of BMI and waist circumference was quoted with phthalate levels of blood.

Another category of xenobiotics - artificial sweeteners may disturbenergy metabolism of human body. It is documented in the study of Brown & Rother (2012), who found enhanced activation of glucose transporting protein after consuming artificial sweeteners in an animal model study. It supports the hypothesis that artificial sweeteners may alter carbohydrate metabolism. However, no significant changes were observed in glucose levels or insulin secretion after administering aspartame, sucralose, saccharine or acesulfame K. Risk of developing colon cancer highly depends on gut microbiota that may be altered by xenobiotics (Nogacka *et al*., 2019).

In different cell culture studies; it was found that different artificial sweeteners; e.g., saccharine, sucralose, acesulfame K increase glucose induced insulin production by β cells of pancreas (Suej *et al*., 2014). Therefore these compounds are responsible to release excessive insulin, ultimately causing insulin resistance as well as these causes an alteration in intestinal microbiota.

Many researchers have demonstrated role of artificial sweeteners in increasing obesity by alteration of gut microbiome. Among all artificial sweeteners, saccharine plays strongest role followed by sucralose.

Generally different nutrient deficiencies are known to reduce the metabolic rate of xenobiotics. However, in the study of Yang *et al.* (1992), it was observed that deficient levels of thiamine and riboflavin enhanced the rates of xenobiotic's metabolism.

Protection from xenobiotics / endocrine disruptors

Xenobiotics clearance from the body occurs by xenobiotic metabolism. It happens mostly in liver by deactivation and excreted out in faeces, urine, sweat and through respiration. The process of xenobiotic clearance is comprised of their activation in liver, conjugation of active secondary metabolite with glucuronic acid or sulphuric acid and then these are excreted out in bile or urine. Enzyme hepatic microsomal cytochrome P450 is the main enzyme involved in xenobiotic clearance, therefore these are very important in pharmaceuticals as breakdown of many drugs also depends on this enzyme only.

Microorganisms may also be used to get rid of environment pollutant compounds by using them as an energy source, the process being termed as bioremediation (Singleton, 1994). Bioremediation process involves genetically engineered microorganisms and isolated natural microbes. Research has been carried out to identify & separate the genes from the micro-organisms, which are involved in xenobiotic metabolism micro-organisms produced with these modified genes can be used for harmful xenobiotic metabolism (Diaz, 2004).

As per Singh (2004), a single microorganism may not be sufficient for metabolism and clearance of a xenobiotic compound therefore, "syntrophic bacterial consortia" may also be developed. In this process, group of bacteria work together as product of one type of bacteria and is used by other as an energy substrate.

To minimize xenobiotic toxicity, pesticides should be analyzed for risk factors before sale in market (Wikipedia).

Various indoor activities like the cooking, use of cleaning agents, smoking, use of air conditioner affect the indoor air quality. The indoor environment affected by the xenobiotics can be very toxic and harmful to the occupants. Hence periodic monitoring of the ventilation systems in the indoor spaces are required (Ramaka *et al*., 2020).

There are certain dietary compounds that are known to reduce xenobiotic toxicity and act as anti-carcinogenic compounds. Besides this, endocrine disruptor's harmful effect may be prevented by increasing their excretion from the body (Ching, 2017).

Conclusion

From the above analysis, it is evident that certain foreign compounds may be toxic for human body that may influence our hormonal mechanism or DNA damage. These are termed as xenobiotic or endocrine disruptors. To prevent mankind from this inevitable matter, one can reduce or delay health risk by following some general guidelines as following -

- Thorough hand washing is recommended after using industrial products like paints, fertilizers, adhesives, cleaning agents and lawn and garden treatments
- Avoid use of or exposure to these products as far as possible
- Children should be kept away from these products
- Fruits and vegetables should be washed thoroughly
- Avoid the consumption of artificial sweeteners
- Organic foods should be promoted to reduce risk of pesticides/ insecticides
- Use of organic or bio fertilizers should be promoted
- Retard or minimize consumption of high fat non-vegetarian products that are high in endocrine disrupting chemicals and may be passed from previous generations
- Drinking water should be pure
- Minimize use of plastic in food packaging
- Iodine intake should be maintained in sufficient quantities to minimize the effect of exposure to perchlorate

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