Prezentat la 1st INTERNATIONAL U.O.C. – B.EN.A. conference „The sustainability of pharmaceutical, medical and ecological education and research – SPHAMEER - 2013”, under section **Environmental Pollution (air - water - soil)**

REGULATION OF CONCENTRATION OF CHEMICAL SUBSTANCES INCLUDING HAZARDOUS ONES-A SCIENTIFIC CHALLENGE

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The paper presents a commented comparison of different standard limits for chemical substances including the priority/priority hazardous substances in order to protect the good and very good quality of drinking water as the Water Frame Directive requires for preserving population health and safety. A short review of the regulation efforts is presented underlying the scientific evidences behind keeping those standards updated with the latest research in the field. Example of Romanian legislation requirements for keeping under control the water bodies’ discharges of priority/priority hazardous substances and comments related to the necessity of a mature judgment in applying it are presented in conjunction with the European and international practices.

Key words: priority substances, standard limits, drinking water

1. Introduction

The access to good water quality represents a fundamental human right. WHO - World Health Organization is embarked, along with other international organizations such as UNO-United Nations Organization, in a common effort to offer reviewed International Environmental Standards and Guidelines for Quality of Drinking Water. They assist the development of customized national standards for hazardous chemicals based on an on-going review process of new scientific evidences for chronic exposure through regularly consumption of 1-2 L/day drinking water during life time[1]. The usual ways to identify the hazardous chemicals is screening their persistence, bioaccumulation and toxicity properties abbreviated as PBT (English acronym for Persistent Bio-cumulative and Toxic). However, with all common efforts, the endeavor of establishing limits for such substances represents a real scientific challenge because of the following essential reasons: they are dangerous in very small concentrations, the metabolic paths and their levels of toxicity for aquatic life ecosystem and for humans are different; the regulation limits are based on sensitive species exposure models and extrapolation to other species brings uncertainty; they may become of concern only after long periods of chronic exposure. The present paper reviews some of the newest relevant aspects in connection to human toxicology and pathology of the priority/priority dangerous substances and the challenge in establishing their standard limits. Metals for example, as microelements, are essential for living cells and for most of them, there are storage/excretion mechanisms different among species but also within the same species making difficult research results extrapolation. A relevant example in this idea is the absorption of ingested zinc in humans that is highly variable (10-90%) [2] .

2. Possible toxic action mechanisms of priority/priority hazardous substances and health concerns.

Priority/priority hazardous substances can be roughly classified in: volatiles, semi-volatiles and heavy metals. The volatiles/semi volatile compounds although have a high toxicity for human body their potential of being bio-accumulated and persistent in aqueous phase is smaller due to their organic nature. The contamination level in drinking water all over the world is on average in the range of ppb (0.2-1μg/L) and the actual standard environmental requirements to be fulfilled by 2027 for European water bodies is also in the range of ppb (0.02-0.05 μg /L). However, because of their demonstrated or suspected gene toxicity, the volatile/semi volatile substances included in the list of priority substances by Water Frame Directive (Directive 2000/60/EC) such as 1,2-Dichlorethan, 1,2-Diclorethene, benzene, benzo(a) pyren, Di-(2-ethyl-hexyl) phthalate, in Romania, have even stricter limits than those recommended by WHO Guide 2008. This is done subscribing to the idea that for such substances it is believed there is no such notion of safety concentration. Apart from volatiles and semi-volatiles in drinking water, heavy metals are also of real concern. Their biochemical reactions are governed by rules of coordinative chemistry. Heavy metals have the necessary flexibility to realize contextual local bonds depending on local electronic surrounding necessities and conditions. Metals can be linked to different partners but proteins are the preferred ones. The difference among heavy metals is related to how strong they can be linked to a protein in different compounds - alkaline phosphatase with Zn has a double binding energy (ΔF = -11,000 cal) when comparing with that of leucine amino-peptidase with Mn (ΔF = -6,000 cal) - and how available are their electrons for different reactions, especially for the catalytic ones [3]. For example, Zn is part of almost 200-300 enzymes in the human body but the real issue, for the regulation purpose of daily intake for those microelements, is that the more the metal is largely distributed in different cells /tissues the less it can be controlled when it comes to its homeopathic excess or deficit. The biological half time of retained zinc in humans is for example about 1 year and recommended daily intake is about 10-15 mg/mass body[2] .That is explained because metabolic dynamic conditions that make heavy metals temporarily available at different sites, make them ready available to catalyze both beneficial and non-beneficial reactions. Of great interest are radical reactions leading to other radicals or to other compounds known as ROS (English acronym for Reactive Oxygen Species). When they arise as a normal cell metabolic reactions result, the detoxification cells mechanisms transform them in non-harmful species (H_2O and O_2) using enzymes such as superoxide-dismutase and catalase, largely distributed in the human body cells containing themselves heavy metals such Mn, Cu, Zn and Fe. They have an exceptional turnover but their detoxifying conversion efficiency is not all the time 100% due to a lack of sufficient enzymes at ROS generation site. This can be attributed to a variety of causes, one being the natural variability in the enzyme expressions among individuals at different tissues levels that in humans accounts for about 30 %. That makes different individuals more or less vulnerable to radicals and ROS attack, and ROS linked diseases development. That might be one of possible reliable explanation for the high variability outcomes in toxicological studies among individuals exposed to the same stress conditions and the impossibility to draw cohort study clear-cut conclusions. Occurrence of different parallel/concurrent inhibitory reactions make those enzyme inactive for detoxification. When the cell detoxifying capacity is exceeded, especially during stress events, residual H_2O_2 can persist in cells and might enter in other radical reactions catalyzed by locally, contextual available heavy metals depending on locally ROS availability. The process can become this way the main source of other radical species (OH.) even more dangerous than the initial residual H_2O_2 in Fenton like type reactions especially at the nervous tissue level being linked to the natural or pathological neurodegenerative phenomena[4,5,6,7,8] They can interfere in cell signaling process[9], and mitochondrial respiration to name only the two most important processes, attacking the cell constitutive lipids/proteins including cellular DNA and RNA[10] . ROS are known to exaggerate site inflammation, by the recruitment of more leucocytes at the damaged tissues causing the exacerbation of cells destruction. There is a lot of new evidences mentioning that chronic (repetitive) inflammatory responses might be linked to some of modern world pathologies and neuropathologies [9,11,12] . For example in rheumatoid arthritis, ROS are involved in lesions of the polypeptide part of the proteoglicans [13] and in lung pathologies in the inhibition of proteases activity[14]. In atherosclerosis they are linked to the increasing effect on LDL(Low Density Lipoprotein) rate of absorption by macrophages [15] and in neurodegenerative pathology - due or not due to normal aging process - to the locally metal catalyzed reactions. For e.g. lipofuscin (LF) - coming from mitochondria and/or lissosome oxidative degradation processes within the Purkinje cells – contains metals such as Fe, Cu, Zn, Al, Hg and pyrrole fragments from heme aging degradation process pointing towards Fenton like type reactions.

3. Possibility of fulfilling recommended environmental standards concentrations and legal frame

Recognizing the fact that costs of monitoring these substances might be sometimes prohibitive for economic operators who discharge different chemicals in sewerage system; Romanian legislation requires first an operator's site audit to document real and potential hazards. The audit helps to establish monitoring requirements and create operators' awareness about the risk posed by those substances. During audits of the economic agents discharging in the Bucharest municipal sewage between 2010 – 2012, the auditors found most priority/priority hazardous substances being in the required range of concentrations. It should be mentioned that in Romanian legislation neither the limits for sewerage system nor for drinking water are not exceeding the recommended healthy safe limits recommended by WHO 2008. However, there is room for improvement in the sense that more attention should be given when it comes to establish limits for those metals whose metabolic activities can be interconnected such as Fe, Zn, and Cu [12,15,16,17]. If copper in food (organic copper) is processed by the organism via entero-hepatic path and is sequestered in a safe manner, the inorganic copper (from drinking water and copper supplements) enters the blood by-passing the liver and become potentially toxic being able to penetrate blood/brain barrier[(cited18)] Although there is an efficient copper homeostatic mechanism, ROS and excessive levels of copper can result in liver and kidney damage, anemia, immunotoxicity and developmental toxicity. Very low level of cooper (deficiency) might inhibit angiogenesis, thus preventing the growth of tumor cells or an inflammation to spread. In this regard the control of copper levels can be potentially used as a strategy in the therapy of cancer or against neurodegenerative diseases [11] .

Conclusions

Taking into account the high detrimental effect that chemicals including priority/priority hazardous substances might have on population health, any joined effort of establishing adequate safe limits is justified by the known fact that it is easier to prevent than to treat.

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