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Evaluation of Concentrations of Heavy Metals in Water Used in Agricultural Irrigation

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Abstract

The knowledge about toxic levels of toxic heavy metals in irrigation water is very scarce and quite varied. This work aimed to evaluate the concentrations of toxic heavy metals in the lake of the Experimental Farm UEMG, Passos-MG Unit. The toxic heavy metals evaluated were Cadmium (Cd), Chromium (Cr) and Lead (Pb). The lagoon was divided into ten strategic points for sampling, each point being sampled in triplicate. The pH of the water and the concentrations of toxic heavy metals present were evaluated. PH measurements were performed on the water in natura, being measured before and after filtration. Values ranging from 6.25 to 7.75 were found. For the determinations of Cd, Cr, and Pb, an Atomic Absorption Spectrophotometer was used. The samples were treated with acid digestion. The values of toxic heavy metals found were: Cadmium: 0.727 mg/L at 0.754 mg/L; Chromium: 0.177 mg/L at 0.256 mg/L and Lead: 0.023 mg/L at 0.081 mg/L. These values are above the limit established by CONAMA 357/2005. The dangers of contamination of water by toxic heavy metals are not restricted only to the direct consumption of this water, but also to the consequences in the food chain when we refer to bioaccumulative toxicants.

Subject Areas

Environmental Chemistry

Keywords

Heavy Metal, Agricultural Irrigation, Surface Water

1. Introduction

Water is one of the most vital and perhaps one of the most precious assets of the world's population, but its global situation is worrying. Its quality has been affected mainly due to the contamination by anthropic activities, which has been aggravated in the last years. Water is a fundamental means of life and indispensable to a wide range of human activities, such as public and industrial supplies, agricultural irrigation, electric energy production and leisure and recreation, as well as the preservation of aquatic life [1].

Some heavy metals are highly toxic substances and are not compatible with most biological treatment of existing effluents. Toxic heavy metals occur in the aquatic environment in various forms: in ionic solution or in the form of organic or inorganic soluble complexes [2].

Recently, there has been a major concern in food associated with health risks arising from the release of toxic contaminants. Among the main contaminants are the toxic metals, because they are extremely persistent in the environment and accumulate in plant cultures [3].

Heavy toxic metals in excess can cause many diseases and serious physiological problems, since they are cumulative in the human body. The residues containing cadmium and chromium have high contamination power, and it is easy to reach the water table [4].

Heavy metals are chemical elements (metals and some semimetals) that have a density greater than 5 g/cm^3. They are generally toxic to living organisms and are therefore considered pollutants [5].

The toxicity of heavy metals dissolved to plants and animals is entirely dependent on the concentration of metals in the free form (dissolved in the water column) [6].

The parameters analyzed for an adequate interpretation of water quality for irrigation should be related to their effects in each crop, as well as in soil and irrigation management, thus avoiding problems with public health [7].

Monitoring of toxic wastes in fruits and vegetables is essential to protect consumers, and to verify compliance for good agricultural practices and to ensure trade activities. Good agricultural practice can be understood as the correct and effective use of agrochemicals and fertilizers and water for irrigation, considering the possible toxicological risks involved in their application, so that the residues are the smallest possible and toxicologically acceptable [8].

Toxic heavy metals

Cadmium

Cadmium (Cd) has a dermal, respiratory and gastrointestinal absorption. It has been found in various organs such as the pancreas, testis, thyroid, salivary glands and heart, among others. The kidney is the organ in which a critical concentration of cadmium is first reached as a consequence of the accumulation of this metal. The renal cortex is the region where cadmium is most concentrated. Cadmium intoxication is characterized by renal damage with proteinuria. Cadmium also has an effect on the nervous system, having repercussions on the visual system, on the smell, or provoking polyneuropathies and diverse neurological alterations. Neuropsychological effects are also attributed to exposure to cadmium, such as changes in memory, cognitive and psychomotor velocity, among others [9].

Chrome

Chromium (Cr), is also a heavy metal of high hardness, much used in the field of metallurgy to increase resistance to corrosive agents. The most common oxidation states of chromium are: Cr^{+3}, Cr^{+6}. They are more stable in tri and hexavalent forms, besides the elemental form. Most of the toxic effects induced by chromium occur in the respiratory tract, when the route of introduction is pulmonary. Some systemic effects are reported in very high concentrations, but usually of lower prevalence. Toxic effects in occupationally exposed individuals at high concentrations of chromium, particularly chromium (VI), include nasal septum ulceration and perforation, respiratory tract irritation, possible cardiovascular, gastrointestinal, haematological, hepatic and renal effects, as well as elevated risk of cancer pulmonary function [10].

Lead

Lead toxicity (Pb) generates from clear or clinical effects to subtle or biochemical effects. The latter involve various organ systems and biochemical activities. In children, the critical effects affect the nervous system, whereas in adults, with excessive or even accidental occupational exposure, the care is with peripheral neuropathy and chronic nephropathy. In rare situations, the effects on heme synthesis provide indicators of exposure to lead in the absence of chemically perceptible consequences. Also the gastrointestinal and reproductive systems are the target of lead intoxication [11].

2. Materials and Methods

2.1. Samples

The present research was carried out with an investigative character, to obtain information about the presence of toxic heavy metals Cd, Cr and Pb. These metals are not essential to the growth of vegetables, but can cause serious problems for the environment, as well as for the organism human.

The research was carried out in the UEMG Experimental Farm lake, Passos-MG Academic Unit (**Figure 1**). The lake was divided into ten strategic points for sampling. For pH analysis, plastic flasks were used, and 200 mL of water were collected for triplicate measurements. PH measurements before and after filtration were performed in the "in natura" water without pretreatment.

For analysis of toxic heavy metals, the collection was carried out in polypropylene flasks with a lid, and 1000 mL of water was withdrawn per flask. For determination of Cd, Cr, and Pb, the samples were treated with acid digestion. The equipment used was a Perkin Elmer Atomic Absorption Spectrophotometer-model PINAACLE 900 T.

At the sampling points, the flasks were opened for collection of water, avoiding the contact of the mouth of the bottle with the hands or any metal object that

Source: Google Earth.

Figure 1. Approximate area of the experimental farm lake: 40,600 m^2.

causes problems of contamination, avoiding air space over the liquid. The flasks were closed immediately after sample collection and shaken for complete homogenization of the preservative, as three bottles of water were collected for each sampling point. 0.5 mL of 40% HNO_3 (nitric acid) was added to 100 mL of sample.

2.2. Reagents and Solutions

All reagents used in this work have analytical purity (P.A.), without any purification.

3. Analytical System

pH Measurements

The pH measurements in the water samples were performed in natura, without any previous treatment. A pH meter brand LOGEN mod. LS300.

Analysis of Toxic Heavy Metals

The concentration of the metals Cadmium (Cd), Chromium (Cr) and Lead (Pb) were determined with acid digestion of the samples, and the solutions obtained were analyzed in a Perkin Elmer Atomic Absorption Spectrophotometer-PINAACLE 900 T model, at Institute of Chemistry of São Carlos-IQSC, University of São Paulo, Brazil, in the Central of Instrumental Chemical Analyzes (CAQI).

4. Results and Discussion

The values of toxic heavy metals found were: Cadmium: 0.727 mg/L at 0.754 mg/L; Chromium: 0.177 mg/L at 0.256 mg/L and Lead: 0.023 mg/L at 0.081 mg/L. Significant amounts, however, are above the limit established by CONAMA 357/2005 as shown in Table 1 & Table 2. The hazards of contamination of water by toxic heavy metals are not restricted only to the direct consumption of this water, but also to the consequences in the chain when we refer to bioaccumulative toxics (Figures 2-4).

The mean pH values for water at all collection points were classified as low (pH < 7.0), indicating that there was no risk of obstruction to the localized irrigation system. Very low pH values can cause corrosion and high values can cause scale problems in pipes. Regarding the electrical conductivity, there was a low risk of water obstruction at all points of collection [12].

Table 2 Concentrations of toxic heavy metals (Cd, Cr, Pb) from samples of irrigation water collected in the lake.

Table 3 Concentrations of toxic heavy metals (Cd, Cr, Pb) from samples of irrigation water collected in the lake. Compared to the specification required by Conama 357/2005.

Table 1. Average values and pH standard deviation of irrigation water.

Samples	pH before filtration (average value)	pH after filtration (average value)
1	7.27	7.07
2	6.97	7.08
3	6.95	6.96
4	6.65	7.1
5	6.51	6.98
6	6.73	7.08
7	6.55	7.07
8	6.61	6.87
9	6.54	7
10	6.5	6.98
Average	**6.728**	**7.019**
Deviation	**0.2556**	**0.0732**

Table 2. Average values and standard deviation of toxic heavy metals.

Samples	Cd(mg/L)	Cr(mg/L)	Pb(mg/L)
1	0.727	0.245	0.023
2	0.746	0.247	0.081
3	0.75	0.222	0.068
4	0.751	0.224	0.058
5	0.751	0.214	0.048
6	0.753	0.207	0.072
7	0.754	0.256	0.058
8	0.751	0.215	0.08
9	0.752	0.213	0.07
10	0.751	0.177	0.066
Average	**0.7486**	**0.222**	**0.0624**
Deviation	**0.0079**	**0.0230**	**0.0172**

Table 3. The results of heavy metals presents in irrigation water.

Heavy Metals	Cadmium	Chrome	Lead
Average value obtained (mg/L)	0.749	0.222	0.062
Specification Conama 357/2005 (mg/L)	0.005	0.05	0.01

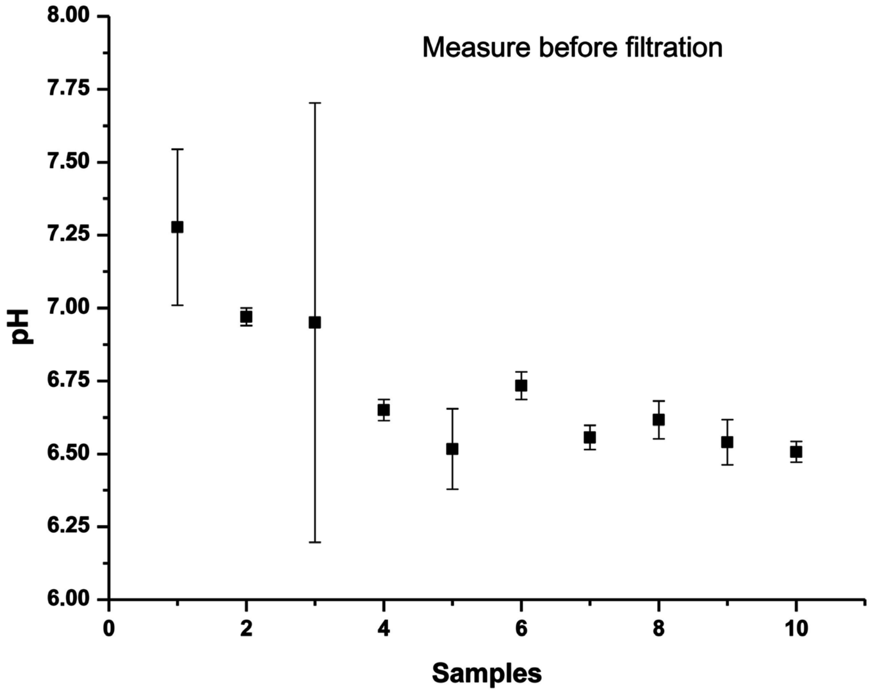

Figure 2. pH values found in the samples of irrigation water prior to filtration.

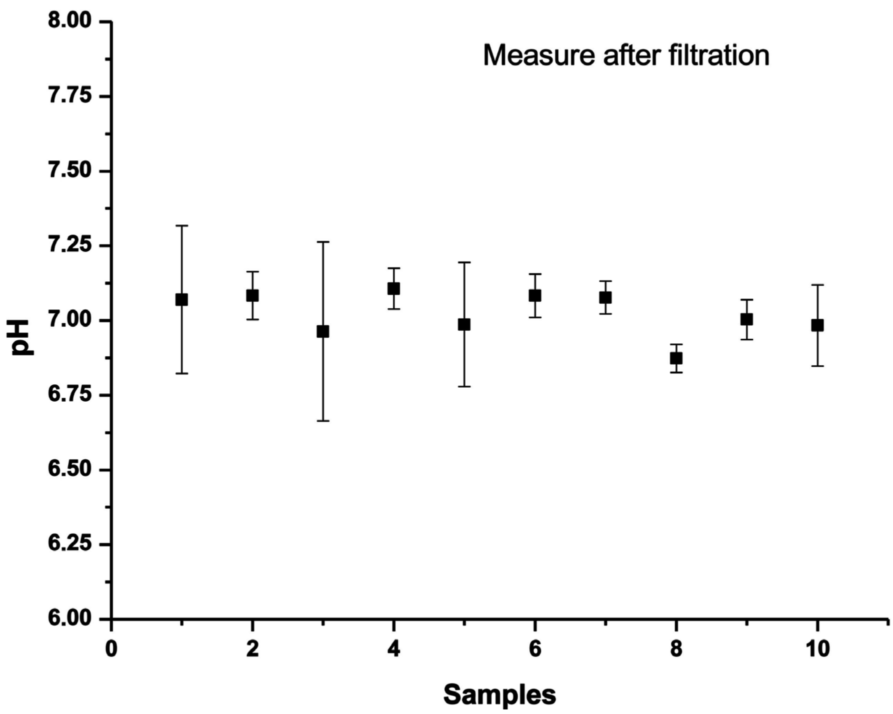

Figure 3. pH values of samples at irrigation water after filtration.

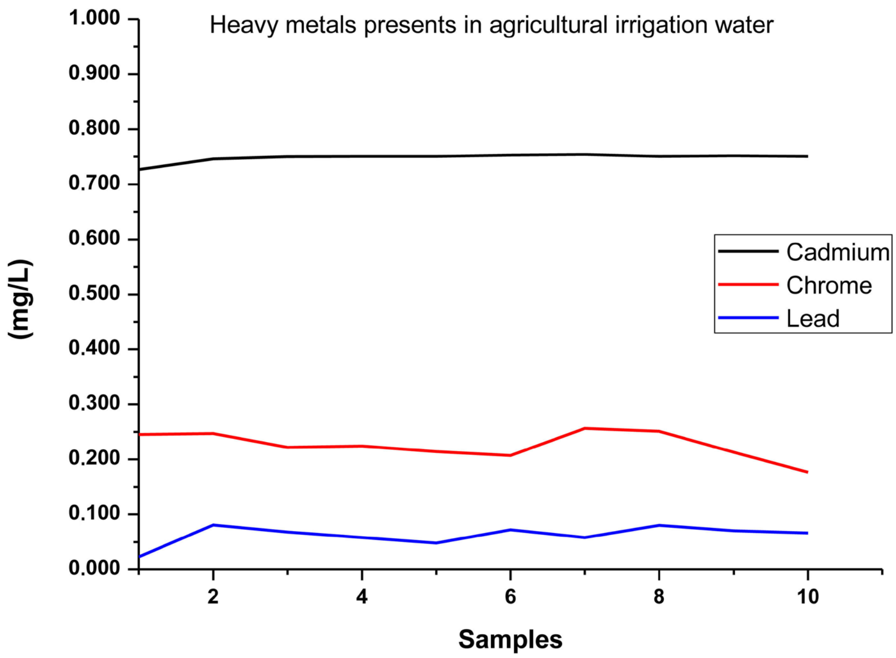

Figure 4. Heavy metals obtained at water samples.

5. Conclusion

It is concluded that the values of toxic heavy metals are above the limit established by CONAMA 357/2005, being of extreme importance the analysis of these heavy metals also present in plants and soil, irrigated by this same water. Therefore, we suggest the construction of a treatment unit near the lake in the municipality of Passos-MG, using polyurethane foams derived from vegetable oil subjected to acid treatment for the adsorption of these toxic heavy metals, which may be bioaccumulative, causing damage to the human health and damaging the environment.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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