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Analysis of the Content and Leaching Tendency of Chromium, Magnesium, Zinc, Cesiumand Manganese from Clays into the Water

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Abstract

Clay is an economically valuable earth material which is found in a large number of certain locations around the world. In the utilizations of this earth resource, it is used in the preliminary purposes such as the pottery industry and roof tile manufacturing even though it would be much applicable material/agent for the sake advanced uses because of the variations in the physic-chemical characteristics of most of different clay verities foremost of the adsorption. The investigations of the leaching of some metallic elements to water were the aims and objectives of the existing research component prior to the choosing for the water treatment systems. In the existing research there were experimented three different types of clay types available in Sri Lanka. A few of clay samples from each of clay was dissolved in distilled water and prepared a batch of solutions after filtering each of them. The prepared solutions were analyzed using Atomic Absorption Spectroscope (AAS) for Cr, Mn, Mg, Zn and Cs. As the general outcomes of the relevant analysis, there were obtained 0.8883ppm, 7.4808ppm and 2.003ppm of Cr in anthill clay, brick clay and roof tile clay and 1.8640ppm, 3.1952ppm and 1.1408ppm of Mg in anthill clay, brick clay and roof tile clay. Also there were obtained 0.1059ppm, 0.0632ppm and 0.0863ppm of Mn in anthill clay, brick clay and roof tile clay. When comparing of the obtained results with the Sri Lankan drinking water quality norms there was found some non-hazardous conditions as the maximum permissible limits of Chromium (Cr), Magnesium (Mg) and Manganese (Mn) for drinking water are 0.05ppm, 150ppm and 0.5ppm. The long term effects on the human health as results of the long term contaminated/ non-recommended water consumption and accumulation of such elements.

Keywords : Clay, leaching, Chromium, Magnesium, Zinc, Cesium, Manganese.

Introduction

Clay is an unreal earth material having unique and distinguished properties that differ from some other types of soils. When considering the chemical and mineralogical contents of clays, usually they can be considered as multi elemental materials with a vast variation in mineralogy such as kaolinite, montmorillonite.

When considering the industrial applications of different clay types, the waste water treatment applications can be emphasized as a foremost utilization. Due to the chemical phenomenon of adsorption and physical phenomenon of filtration clays play a dominant role in the wastewater treatment industry. In the consideration of adsorption impact on waste water treatment, most probably the dissolved heavy metals, pathogens and particulate matter are removed using different clay types (Ahmaruzzaman, 2011).

Also it was identified a few of clay varieties as high performance adsorbers and filter materials in different water treatment purposes such as the removal of dissolved heavy metals, pathogens (BOD, COD), dissolved solid particles (color), suspended solid particles (color) and odor (Kurniawan et al., 2006). When considering the merits and demerits of adsorbers some important circumstances are shortlisted in the Table 1.

Merits	Demerits
Recovery/separation method, high performances (certain period), relatively low cost method, convenience in the operations, no special requirements in background conditions (pH, chemical composition)	Generation of inactive waste materials, requirements in the replacements of the system, inconveniences in selectivity, variations of adsorption capacity

Table 1: Contrast of merits and demerits of using adsorbers/ adsorbents

Research Problems

In the applications of different clay types in the wastewater treatments, it is possible to be found some adverse impacts such as the back contaminations of treated water with some unnecessary/ toxic compounds which are available in the contacted materials such as clay and activated carbon. In the consideration of leaching materials from clay into water, predominantly there were found some metals, organic matter, and solid particles. The metallic contamination would be an important concern regarding the applications of different earth materials in the drinking water treatment uses and food industrial uses that associated with the hazardous conditions.

Objective

In the existing research component, there were expected to test and analyze the leaching amounts of the following metals form each of the following clay verities under the general conditions of contact in their raw form.

Element	Chromium (Cr)	Manganese (Mn)	Magnesium (Mg)	Zinc (Zn)	Cesium (Cs)
Clay Type 1	√	√	√	√	√
Clay Type 2	√	√	√	√	√
Clay Type 3	√	√	√	√	√

Table 2: The selected elements and clays

Theoretical Considerations and Empirical Evidence

Adsorption

Adsorption is a process that a transferring of a substance from a gaseous or liquid phase onto a specific surface of a solid material due to the occurring electrostatic forces in between such solid phase material and the particular substance either in gaseous phase or liquid phase. When considering the components of the adsorption process, the transferring substance is known as the "adsorbate" and the specific solid material is known as the "adsorber/adsorbent". This is an important process which is much applicable in the industry of wastewater treatments (Crini, 2006). A few of well-known adsorbers and adsorbates are mentioned in the Table 3.

Adsorber/Adsorbent	Adsorbates
Activated carbon	Heavy metals, pathogens
Clays	Heavy metals, pathogens, dissolved solid particles
Saw dust	Heavy metals, organic matter
Fly ash	Heavy metals, organic compounds
Zeolites	Chemical substances
Graphite	Oils, fats, metals
Polymers	Metals, chemical substances

Table 3: The common adsorbers and adorbates

However, the adsorption capacities of those adsorbers/ adsorbents would be varied based upon the deviations in following conditions.

- Surface area
- Pore spaces in the surface and the relevant sizes of pores
- Functional groups of the surface material

Filtration

In general the filtration is defined as the removal of solid particles in gaseous or liquid medium using an appropriate filter material when it is percolating the gaseous medium or liquid medium through the filter material while retaining the solid particles in the filter medium. The general principle behind the filtration is the sieving and the percolating space would be an important parameter when considering the limitations of the filtration process. The most common example for the filtration of water is sand filtration which is further categorized as the rapid sand filtration and slow sand filtration because of the importance of the flow rates of the fluid or the gas through the filter material regarding the filtration efficiency. Also there can be shortlisted the merits and demerits that associated with the process of filtration as mentioned in the Table 4.

Merits	Demerits
Removals of hazardous materials, removals of toxic compounds, effectiveness in cost, improvement of color and odor of water and removals of particulate matter from water	Requirements of maintenance, selectivity of method and materials, relatively lower filtration outflow, effects of contaminants and toxic compounds presence in filter materials

Table 4: Merits and demerits of using filtration

Leaching

Usually the leaching is known as a transferring of some mass/ compound from a solid material when contacting with some sort of liquid. In the consideration of leaching of some masses/ compounds into water, the leached mass/compound would be a water soluble compound. When considering the component that related with the process of leaching, there can be found some involvements in three components as mentioned in the Table 5.

Component	Examples
Solution/ Solvent	Water, Sodium Chloride, hydrocarbons
Solute	Metals, ions, complexes
Solid matrix	Clay, sand, polymers

Table 5: Components of leaching process

The phenomenon "contact" of solution/solvent and solid matrix is the major requirement for the leaching and the "contact" is the initial stage in the leaching process.

Research Methodology

By considering the abundances of clay deposits in Sri Lanka, three specific areas were selected, and some representative clay samples were collected from such regions as shown in Figure 1.

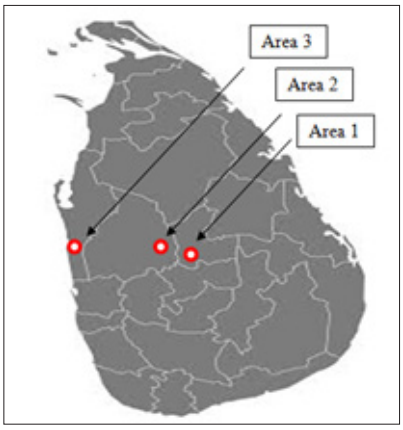


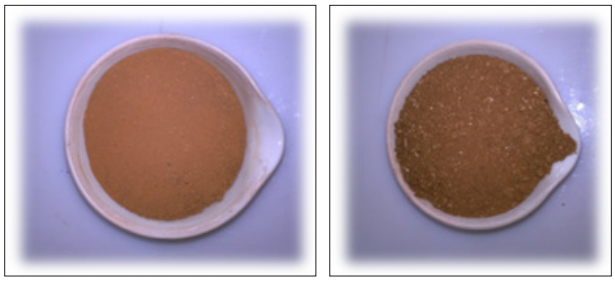
Figure 1: Clay sample collected areas

A descriptive summary of the clay sample collection areas and the applications of such clays have been shortlisted in the Table 6.

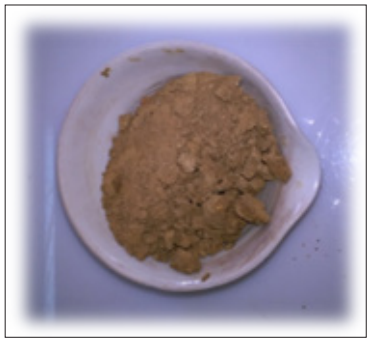
Area	Name	District	Applications
1	Matale	Matale	Building of anthills by termite
2	Maduragoda	Kurunegala	Manufacturing of bricks
3	Dankotuwa	Puttalam	Manufacturing of roof tiles

Table 6: Descriptive summary of collected areas applications of such clays

A few of selected clay specimens are shown in three clay types in the Figure 2.



(a) (b)



(c)

Figure 2: (a) Anthill clay, (b) brick clay and (c) roof tile clay

Sufficient quantity of each clay sample was taken and those samples were oven dried for 24 hours under the temperature 1100C until the mass of each clay bulk becoming content. After drying each clay sample was pulverized by using ceramic crucible and the crushed clay samples were comminuted by using ball mills forever. The sizes of comminuted particles were less than 0.037mm.

(a)

(b)

Figure 3: (a) Ball mill and (b) electrical shaker

According to the sample dissolving methodology, 4g of each clay sample was dissolved separately in 100ml of distilled water and stirred well. The prepared solutions were transferred into three glass bottles. As the precaution and improvement of the solubility and the clay-water interaction, three of clay-water bottles were shaken for three hours by using an electrical shaker under the rotation speed of 150rpm.

Then the well shaken clay- water liquids were filtered by using filter papers and stored separately in well cleaned plastic bottles. The stored liquids were benefitted for the assay of the contents of the elements of Chromium (Cr), Magnesium (Mg), Zinc (Zn), Cesium (Cs) and Manganese (Mn) by the Atomic Absorption Spectrometer (AAS) and also the distilled water was used as the indicator, reference solution or the blank solution for the analysis.

Figure 4: Atomic absorption spectrometer (AAS)

Results and Discussion

According the analysis of metallic contents of clay-water liquid by the Atomic Absorption Spectrometer (AAS), following results were obtained as shown in the Table 7.

Metal	Concentration in Distilled Water (ppm)	Concentration in Anthill Clay Solution (ppm)	Concentration in Brick Clay Solution (ppm)	Concentration in Roof Tile Clay Solution (ppm)
Cr	0.0000	0.8883	7.4808	2.003
Mn	0.0000	0.1059	0.0632	0.0863
Mg	0.0000	1.8640	3.1952	1.1408
Zn	0.0000	0.0000	0.0000	0.0000
Cs	0.0000	0.0000	0.0000	0.0000

Table 7: Metallic contents of clay solutions

According to the drinking water standards of The Board of Investment of Sri Lanka, the following norms were interpreted with respect to the above metals in Table 8.

Metal	Accessible level (ppm)
Cr	0.05
Mn	0.5
Zn	15
Cs	-
Mg	150

Table 8: Accessible levels of such metals in drinking water

A few of graphical comparisons of the leached metals contents into water from each of clay type with the above environmental norms are shown in the following figures.

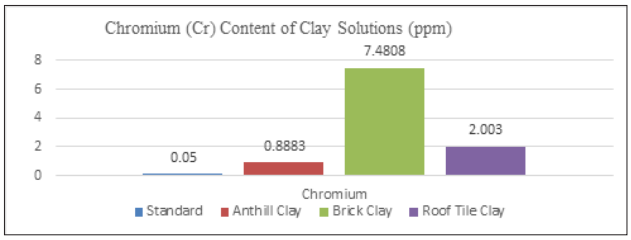


Figure 5: Leached contents of Chromium into distilled water

Chromium (Cr) is considered as a heavy metals which is occurred in rocks and earth materials especially in three valence states. Usually it is difficult to find Chromium in the form of elemental. Usually there were found trivalent Chromium and hexavalent Chromium in water. Chromium (Cr) is an essential element regarding the food digest systems of the body that associated with the proteins and metabolic activity. When considering the toxicity of that element or other alterative form of it, the hexavalent form is more toxic than other forms of the element. In the overall consideration of the toxicity of chromium, there were confirmed the impacts of chromium on the breathing systems of humans and animals such as the causes of lung cancers and coughing. However, it was identified some rare cases regarding the kidney diseases with the excess amount of chromium consumption. According to the above studies and results, it seems that there were found some hazardous conditions with the norms and recommended limits. Therefore, it is much important to prevent the excess leaching of this element into water even using a possible prior extraction method, if this clay types will be utilized in waste water treatment applications.

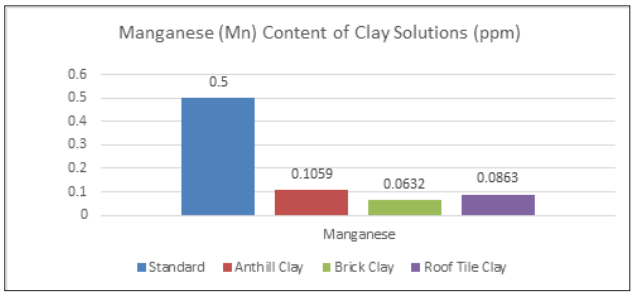


Figure 6: Leached contents of Manganese into distilled water

Manganese (Mn) is an abundant element in the upper part of the earth crust including the part of top soil. In the consideration of the oxidation states of Manganese (Mn), the divalent form is more stable. Manganese is an essential element regarding the nutrition of both plant and animal that insets through different foods and beverages into animal and plant digest systems.

When considering the toxicity of such element and its forms, the element is bit toxic with the higher consumption. Usually the metal manganese is found in the soils as the complexes. According to the above experiments there were found some non-toxic conditions because of the leached Manganese contents were appeared below the environmental norms.

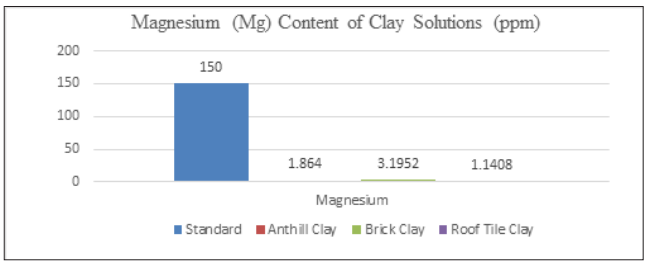


Figure 7: Leached contents of Magnesium into distilled water

Magnesium (Mg) is an abundant element in the upper part of the earth crust including soil, rocks and most of earth materials. Also magnesium is an essential element for the human body because of the involvement in metabolic activities. It was also observed non-toxic conditions with the existing investigation when comparing the obtained results.

Zinc (Zn) is also a naturally occurring element which is also mostly found from the upper crust of the earth. It is found in different mineralized forms in the earth. This is also identified as an essential element/ nutrient for the human body because of the stability in metabolic processes. As it is a reactive element, usually it is found as the compounds in the nature also with some of toxic compounds. According to the above results it was not found any effect from such metal on the water.

Cesium (Cs) is a naturally occurring element which is found in soil and rocks that closer to the upper crust of the earth. In generally there is no any affordable reason to consider such element as a radioactive element in its stable form. Especially it is possible to be released the radioactive forms of such element as the results of nuclear reactions. Cesium is considered as a water soluble element including the dissolving of the element in the soil moisture. It cases a few of known diseases such as stomach, poison in blood and cancers especially in their radioactive forms. It was not found any impact or any toxicity with respect to the above experimental results as there were observed all of the negative results.

Usually the leaching of metals/metallic elements/ions from soils into water is depended on the conditions of both water and relevant soil which is also defined as the solubility of metals which is associated with the following conditions (Geus et al., 2005).

- pH of the soil and water
- Ion exchanging capacity
- The present form of the metal (element, ion, complex etc.)
- Oxidation potential

Sometimes the leaching process will be mitigated with the following forms of raw materials/clays.

- Heat treated/ burnt
- Extracted raw material
- Purified nano-materials

Conclusion

According to the study of the leaching tendency of metals from three different types of selected clays in their raw forms, there were observed some excess amounts of Chromium into water from each of clay type rather than the followed environmental norms of the country, leaching of Manganese and Magnesium from each and every clay type in lower amounts much below the environmental norms and there were not found any leaching of neither Cesium nor Zinc into water from any of clay type. When considering the results and the purposes of the existing study, it can be emphasized some adverse impact from the element Chromium regarding the water treatment applications which can also be mitigated while using an appropriate extracting method, in different forms of clays or using an appropriate adsorber/adsorbent only for hazardous materials.

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ABBREVIATIONS

BOD : Biological Oxygen Demand
COD : Chemical Oxygen Demand