Lesson 18

Title of the Experiment: Treating a water sample using alum and sunlight
(Activity number of the GCE Advanced Level practical Guide – 30)

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Introduction

A number of chemical methods are used for water treatment at point-of-use or entry and for community water systems. These methods can be grouped into several main categories with respect to their purpose and the nature of the technology. The main categories to consider here are: (1) chemical pre-treatments by coagulation-flocculation or precipitation prior to sedimentation or filtration, (2) adsorption process, (3) ion exchange processes and (4) chemical disinfection processes. All of these processes can contribute to microbial reductions from water, but the chemical disinfection processes are specifically intended to inactivate pathogens and other microbes in water. Therefore, chemical disinfection processes are appropriate for household water treatment in the developing world. Other chemical methods for water treatment have been examined for their efficacy in microbial reductions and their applicability to water treatment.

Chemical precipitation or coagulation and flocculation with various salts of aluminum (e.g., alum), iron, lime and other inorganic or organic chemicals are widely used processes to treat water for the removal of colloidal particles (turbidity) and microbes. Treatment of water by the addition of chemical coagulants and precipitants has been practiced since ancient times, even though the principles and physico-chemical mechanisms may not have been understood. Sanskrit writings refer to the use of vegetable substances, such as the seed contents of *Strychnos potatorum* and *Moringa oleifera*, which are still in use today for household water treatment (Gupta and Chaudhuri, 1992). Judeo-Christian, Greek and Roman records document adding "salt", lime, "aluminous earth", pulverized barley, polenta as precipitants to purify water. Although alum and iron salts are the most widely used chemical coagulants for community drinking water treatment, other coagulants have been and are being used to coagulate household water at point of use, including alum potash, crushed almonds or beans and the contents of Moringa and Strychnos seeds.

Alumina is one of the most widely used adsorbents for the removal of dissolved pollutants from waste water. Various chemical species, especially ions, are known to be adsorbed onto alumina. On the other hand, alumina is a typical support for catalysts. Many kinds of metal supported catalysts are prepared using alumina as their support. These two roles of alumina, i.e., as adsorbent and support, are closely related to each other due to two reasons. Firstly, most supported catalysts are prepared by impregnation. Impregnation is the process in which solid alumina is contacted with liquids which contain various metal precursors. Thus, adsorption phenomena play a crucial role in this process. Since a new phase is formed on the surface of the support after the impregnation process, alumina has been reported to have an essential role in the formation of catalysts active sites. Secondly, alumina used as a catalysts support can adsorb reactants in the course of catalytic reaction. Such adsorption onto support must be taken into account when the conversion and selectivity of the catalyst are calculated.

Addition of alum to calcium containing water;

$$Al_2(SO_4)_{3\,(aq)} + 6H_2O_{(l)} \rightarrow 2Al(OH)_{3\,(s)} + 3H_2SO_{4\,(aq)}$$

$$3H_2SO_{4\,(aq)} + 3Ca(HCO_3)_{2\,(aq)} \rightarrow 3CaSO_{4\,(s)} + 6H_2CO_{3\,(aq)}$$

$$6H_2CO_{3\,(aq)} \rightarrow 6H_2O_{(l)} + 6CO_{2\,(g)}$$

Overall reaction is;

$$Al_2(SO_4)_{3\,(aq)} + 3Ca(HCO_3)_{2\,(aq)} \rightarrow 3CaSO_{4\,(s)} + 6H_2O_{(l)} + 6CO_{2\,(g)}$$

Learning outcomes:

After completing this practical, students will be able to

- develop skills in water sampling
- calculate using stoichiometric ratio
- develop skills in using physical methods in water remediation
- develop skills in using chemical methods in water remediation

Materials / equipment:

Plastic container

Watch glass

Spatula

Electrical balance

Aluminium sulfate

Calcium hypochlorite

water sample/s (5 liters)

water sampling bottles

piece of clean cotton cloth

Procedure:

(1) Collect a water sample in a bucket, pour more water to overflow and brush away most of the floating material with hand.

(2) Using a piece of cotton cloth, filter the water sample into another vessel. The filtered water contains no floating material and less silt.

(3) Take about five liters of water in a plastic bucket and add half a teaspoon of powdered Alum (that is about 50 mg which works out to 10 mg per liter of water) and stir well.

(4) This bucket of water needs to be kept still for about 6 to 7 hours so that the sediments get coagulated and settles down at the bottom.

(5) After about seven hours, most of the dissolved particles will have settled down at the bottom of the bucket. Drain out the clean water into another vessel very slowly without disturbing the sediment.

(6) About half a liter of water is left out in the bucket with the sediments.

(7) The water collected thus may still contain some fine dissolved particles, which can be removed by filtration.

(8) The clean water we got by sedimentation still contains lots of bacteria, so it needs to be disinfected before being used, for example by adding chlorine.

(9) Or it can be disinfected by placing water in transparent glass bottle under sunlight for 4-5 hours.

Note:

The prescribed normal rate is about 2 drops of bleach solution per liter of water. So, it’s better to add about nine drops into the water in the vessel and stir well. This water may smell a little bit of chlorine. Either keeping it open to the air and intermittent stirring for about 30 minutes or using a portable filter to further purify the water will remove the chlorine smell.

The chlorination process kills almost 90% percent of the bacteria present in the water. The prescribed dosage of Alum varies from 5 mg per liter for a relatively clear water to 85 mg for a highly turbid waters like industrial waste. However, the normal dosage for drinking water is about 17 mg per liter.

The dosage of bleaching solution as 2 drops per liter is suggested considering 60 to 70 percent of chlorine available in the bleaching powder. You can increase or decrease the amount by smelling the chlorinated water. More chlorine smell, add some clean water. Add a few more drops in case of no smell. Keeping buckets of water mixed with Alum overnight will give you enough clean water in the morning for use. Over-dosage of Alum may cause temporary dizziness, diarrhea and vomiting (but not dangerous). Bleaching solution is corrosive. Take care not to get your skin or cloth in contact with the solution.

References:

D.R. Chowdhury, I.S. Gupta, and P.P. Chaudhuri, "Additive Cellular Automata: Theory and Applications”, Stevenage, U.K., Vol. 139, Nov. 1992, pp. 469-476.

http://www.who.int/water_sanitation_health/dwq/wsh0207/en/index6.html (2015/06/03)