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WATER – LIFELINE OF ECOSYSTEM (PART 2)



Clean water is virtually inaccessible to the population of Cambodia. Average family earnings total less than US\$1 per day, with the environment exacerbating the poverty, as Cambodians endure annual cycles of flood and drought.

According to UNICEF's 'State of the World's Children' Report for 2005, only 34% of Cambodia's population uses improved drinking water sources. Some 14% of Cambodia's children die before reaching the age of five; around 9.7% dies before age one. Many of these deaths could easily have been prevented. A key part of preventing child deaths and improving survival is providing access to clean water and sanitation facilities

Water purification is the removal of contaminants from raw water to produce drinking water that is pure enough for human consumption or for industrial use. Substances that are removed during the process include parasites (such as *Giardia* or *Cryptosporidium*), bacteria, algae, viruses, fungi, minerals (including toxic metals such as lead, copper etc.), and man-made chemical pollutants.

Many contaminants can be dangerous but depending on the quality standards, others are removed to improve the water's smell, taste, and appearance. A small amount of disinfectant is usually intentionally left in the water at the end of the treatment process to reduce the risk of re-contamination in the distribution system. Many environmental and cost considerations affect the location and design of water purification plants. Groundwater is cheaper to treat, but aquifers usually have limited output and can take thousands of years to recharge. Surface water sources



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should be carefully monitored for the presence of unusual types or levels of microbial/disease causing contaminants. It is not possible to tell whether water is safe to drink just by looking at it. Simple procedures such as boiling or the use of a household charcoal filter are not sufficient for treating water from an unknown source. Even natural spring water considered safe for all practical purposes in the 1800s must now be tested before determining what kind of treatment is needed.

Sources of drinking water

Deep groundwater: The water emerging from some deep groundwaters may have fallen as rain many decades or even hundreds of years ago. Soil and rock layers naturally filter the groundwater to a high degree of clarity before it is pumped to the treatment plant. Such water may emerge as springs, artesian springs, or may be extracted from boreholes or wells. Deep groundwater is generally of very high bacteriological quality (i.e., a low concentration of pathogenic bacteria such as *Campylobacter* or the pathogenic protozoa *Cryptosporidium* and *Giardia*) but may be rich in dissolved solids, especially carbonates and sulphates of calcium and magnesium.

Depending on the strata through which the water has flowed, other ions may also be present including chloride, and bicarbonate. There may be a requirement to reduce the iron or manganese content of this water to make it pleasant for drinking, cooking, and laundry use. Disinfection is also required. Where groundwater recharge is practised, it is equivalent to lowland surface waters for treatment purposes.

Shallow groundwater: Water emerging from shallow groundwaters is usually abstracted from wells or boreholes. The bacteriological quality can be variable depending on the nature of the catchment. A variety of soluble materials may be present including potentially toxic metals such as zinc and copper. Arsenic contamination of groundwater is a serious problem in some areas.

Upland lakes and reservoirs: Typically located in the headwaters of river systems, upland reservoirs are usually sited above any human habitation and may be surrounded by a protective zone to restrict the opportunities for contamination. Bacteria and pathogen levels are usually low, but some bacteria, protozoa or algae will be present. Where uplands are forested or peaty, humic acids can colour the water. Many upland sources have low pH which requires adjustment.

Rivers, canals and low land reservoirs: Low land surface waters will have a significant bacterial load and may also contain algae, suspended solids and a variety of dissolved constituents.

Rainwater harvesting or fog collection which collects water from the atmosphere can be used especially in areas with significant dry seasons and in areas which experience fog even when there is little rain.

Pre-Treatment

Pumping and containment - The majority of water must be pumped from its source or directed into pipes or holding tanks. To avoid adding contaminants to the water, this physical infrastructure must be made from



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appropriate materials and constructed so that accidental contamination does not occur.

Screening - The first step in purifying surface water is to remove large debris such as sticks, leaves, trash and other large particles which may interfere with subsequent purification steps. Most deep Groundwater does not need screening before other purification steps.

Storage - Water from rivers may also be stored in bankside reservoirs for periods between a few days and many months to allow natural biological purification to take place. This is especially important if treatment is by slow sand filters. Storage reservoirs also provide a buffer against short periods of drought or to allow water supply to be maintained during transitory pollution incidents in the source river.

Pre-conditioning - Many waters rich in hardness salts are treated with soda-ash (Sodium carbonate) to precipitate calcium carbonate out utilising the common ion effect.

Pre-chlorination - In many plants the incoming water was chlorinated to minimise the growth of fouling organisms on the pipe-work and tanks. Because of the potential adverse quality effects, this has largely been discontinued.

Clarification

There are a wide range of techniques that can be used to remove the fine solids, micro-organisms and some dissolved inorganic and organic materials. The choice of method will depend on the quality of the water being treated, the cost of the treatment process and the quality standards expected of the processed water.

1. pH adjustment

If the water is acidic, lime or soda ash is added to raise the pH. Lime is the more common of the two additives because it is cheaper, but it also adds to the resulting water hardness. Making the water slightly alkaline ensures that coagulation and flocculation processes work effectively and also helps to minimise the risk of lead being dissolved from lead pipes and lead solder in pipe fittings.

2. Coagulation and flocculation

Together, coagulation and flocculation are clarification methods that work by using chemicals which effectively "glue" small suspended particles together, so that they settle out of the water or stick to sand or other granules in a granular media filter. Many of the suspended water particles have a negative electrical charge. The charge keeps particles suspended because they repel similar particles. Coagulation works by eliminating the natural electrical charge of the suspended particles so they attract and stick to each other. The joining of the particles so that they will form larger settleable particles is called flocculation. The larger formed particles are called floc. The coagulation chemicals are added in a tank (often called a rapid mix tank or flash mixer), which typically has rotating paddles. In most treatment plants, the mixture remains in the tank for 10 to 30 seconds to ensure full mixing. The amount of coagulant that is added to the water varies widely due to the different source water quality. One of the more common coagulants used is aluminum sulfate, sometimes called filter alum. Aluminum sulfate reacts with water to form flocs of aluminium



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hydroxide. Coagulation with aluminum compounds may leave a residue of aluminium in the finished water. This is normally about 0.1 to 0.15 mg/L.

It has been theorized that aluminium can be toxic to humans at high concentrations. Iron (II) sulfate or iron (III) chloride is other common coagulants. Iron (III) coagulants work over a larger pH range than aluminum sulfate but are not effective with many source waters. Other benefits of iron (III) are lower costs and in some cases slightly better removal of natural organic contaminants from some waters. Coagulation with iron compounds typically leaves a residue of iron in the finished water. This may impart a slight taste to the water, and may cause brownish stains on porcelain fixtures. The trace levels of iron are not harmful to humans, and indeed provide a needed trace mineral. Because the taste and stains may lead to customer complaints, aluminium tends to be favoured over iron for coagulation.

Cationic and other polymers can also be used. They are often called coagulant aids used in conjunction with other inorganic coagulants. The long chains of positively charged polymers can help to strengthen the floc making it larger, faster settling and easier to filter out. The main advantages of polymer coagulants and aids are that they do not need the water to be alkaline to work and that they produce less settled waste than other coagulants, which can reduce operating costs. The drawbacks of polymers are that they are expensive, can blind sand filters and that they often have a very narrow range of effective doses.

Flocculation

In flocculation coagulants are used to destabilize the particles. The chosen coagulant and the raw water

Assignment

In groups of 2 pupils, you shall set up a purification test of raw water samples.

1. Set up a water sample of about 10 litres in any container
2. Dissolve the sachet of chemicals given and stir well for 5 minutes
3. Let the water settle down for next 5 minutes. If the water is still turbid, continue to stir till water is cleared
4. Use a cotton T-shirt / cloth and filter the water sample into a clean container
5. Let the water settles for 20 minutes
6. Use a test tube and conduct simple test if you think the water is suitable for drinking (visual, pH indicator, smell)
7. Complete the chemical formulae in the following passages

Background of Purifying Chemicals

Calcium hypochlorite is a chemical compound with formula $\text{Ca}(\text{ClO})_2$. It is widely used for water treatment and as a bleaching agent (bleaching powder). This chemical is considered to be relatively stable and has greater available chlorine than sodium hypochlorite (liquid bleach).



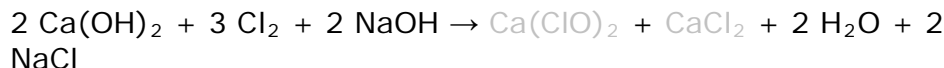
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Preparation

It is manufactured by the calcium process and the sodium process. The calcium process proceeds as follows:



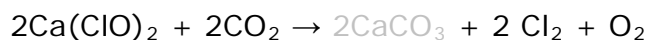
The sodium process proceeds as follows:



Properties

Calcium hypochlorite is a yellow white solid which has a strong smell of chlorine. It is not highly soluble in water, and is more preferably used in soft to medium-hard water. It has two forms: a dry form and a hydrated form. The hydrated form is safer to handle.

Calcium hypochlorite reacts with carbon dioxide to form calcium carbonate and release chlorine:



Calcium hypochlorite reacts with hydrochloric acid to form calcium chloride:



Uses

Calcium hypochlorite is used for the disinfection of drinking water or swimming pool water. It is used as a sanitizer in outdoor swimming pools in combination with a cyanuric acid stabilizer, which reduces the loss of chlorine due to ultraviolet radiation. The calcium content hardens the water and tends to clog up some filters; hence, some products containing calcium hypochlorite also contain anti-scaling agents.

Calcium hypochlorite is also an ingredient in bleaching powder, used for bleaching cotton and linen. It is also used in bathroom cleaners, household disinfectant sprays, moss and algae removers, and weedkillers.

In addition, calcium hypochlorite may be used to manufacture chloroform.

Iron (II) sulfate (Iron (II) sulphate) or ferrous sulfate (ferrous sulphate) is the chemical compound with the formula (FeSO_4) , known since ancient times as copperas. It is most commonly encountered as the blue-green heptahydrate.

Iron (II) sulfate can be found in various states of hydration, and several of these forms exist in nature.

- $\text{FeSO}_4 \cdot \text{H}_2\text{O}$ (mineral: szomolnokite, relatively rare)



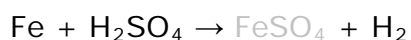
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- $\text{FeSO}_4 \cdot 4\text{H}_2\text{O}$ (mineral: rozenite, white, relatively common, may be dehydration product of melanterite)
- $\text{FeSO}_4 \cdot 5\text{H}_2\text{O}$ (mineral: siderotil, relatively rare)
- $\text{FeSO}_4 \cdot 6\text{H}_2\text{O}$ (mineral: ferroxahydrite, relatively rare)
- $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ (mineral: melanterite, blue, relatively common)

At 90°C , the heptahydrate, also called green vitriol or copperas, loses water to form the colorless monohydrate. In its anhydrous, crystalline state, its standard enthalpy of formation is $\Delta_f H^\circ_{\text{solid}} = -928.4 \text{ kJ}\cdot\text{mol}^{-1}$ and its standard molar entropy is $S^\circ_{\text{solid}} = 107.5 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$. All mentioned mineral forms are connected with oxidation zones of Fe-bearing ore beds (pyrite, marcasite, chalcopyrite etc.) and related environments (like coal fire sites). Many undergo rapid dehydration and sometimes oxidation.

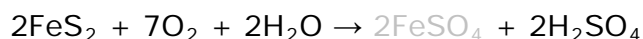
Production and reactions

In the finishing of steel prior to plating or coating, the steel sheet or rod is passed through pickling baths of sulfuric acid. This treatment produces large quantities of iron(II) sulfate as a by-product.



Another source of large amounts results from the production of titanium dioxide from ilmenite via the sulfate process.

Ferrous sulfate is also prepared commercially by oxidation of pyrite:

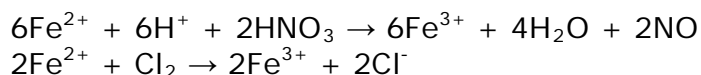


Reactions

On heating, iron (II) sulfate first loses its water of crystallization and the original green crystals are converted into a dirty-yellow anhydrous solid. When further heated, the anhydrous material releases sulfur dioxide and white fumes of sulfur trioxide, leaving a reddish-brown iron (III) oxide. Decomposition of iron (II) sulfate begins at about 480°C .



Like all iron (II) salts, iron (II) sulfate is reducing agent. For example, it reduces nitric acid to nitrogen oxide and chlorine to chloride:



Some Common Uses

Industrially, ferrous sulfate is mainly used as a precursor to other iron compounds. It is a reducing agent, mostly for the reduction of chromate in cement.

Ferrous sulfate was used in the manufacture of inks, most notably iron gall ink, which was used from the Middle Ages until the end of the eighteenth century. It also finds use in wool dyeing as a mordant.



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Ferrous sulfate can also be used to stain concrete and some limestones and sandstones a yellowish rust color. Woodworkers use ferrous sulfate solutions to color maple wood a silvery hue.

It has been applied for the purification of water by flocculation and for phosphate removal in municipal and industrial sewage treatment plants to prevent eutrophication of surface water bodies.

QUESTION

1. What do you think are the actual functions of the chemicals used in purifying the water samples in our assigned case?

2. Why do you think iron sulphate is more favoured chemical compound over aluminium and polymers in our case?
