water & forestry
Department:
Water Affairs and Forestry
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Water Quality
Water treatment processes
Coagulation chemicals

Different chemicals can be used as coagulants. The most common coagulants are aluminium sulphate, ferric chloride, lime and polyelectrolytes. Coagulant-aids are also sometimes used. These are substances added in very small quantities to improve the action of the primary coagulant. The characteristics of the different coagulants and the way in which they function are as follows:

- **Aluminium sulphate** ($Al_2(SO_4)_3.16H_2O$) is commonly used as a coagulant. The alum is dissolved in the water and the aluminium ions (Al^{3+}) that form, have a high capacity to neutralise the negative charges which are carried by the colloidal particles and which contribute to their stability. The aluminium ions hydrolyse and form aluminium hydroxide ($Al(OH)_3$), which precipitates as a solid. During flocculation when the water is slowly stirred, the aluminium hydroxide flocs "catch" or enmesh the small colloidal particles. The flocs settle readily and most of them can be removed in a sedimentation tank.
- **Ferric chloride** ($FeCl_3$) is commonly used as a coagulant. When added to water, the ion precipitates as ferric hydroxide ($Fe(OH)_3$) and the hydroxide flocs enmesh the colloidal particles in the same way as the aluminium hydroxide flocs do. The optimum pH for precipitation of iron is not as critical as with aluminium and pH values of between 5 and 8 give good precipitation.
- **Lime** can also be used as coagulant, but its action is different from that of alum and ferric chloride. When lime is added to water the pH increases, resulting in the formation of carbonate ions from the natural alkalinity in the water. The increase in carbonate concentration together with calcium added in the lime results in the precipitation of calcium carbonate ($CaCO_3$). The calcium carbonate crystals enmesh colloidal particles in the same way as alum or ferric flocs. When lime is used as a coagulant, the pH has to be lowered in order to stabilise the water chemically. Carbon dioxide is normally used for this purpose.
- **Polyelectrolytes** are mostly used to assist the flocculation process and are often called flocculation aids. They are polymeric organic compounds of long polymer chains that act to enmesh particles in the water. Polyelectrolytes can be cationic (carrying a positive charge), anionic (carrying a negative charge) or non-ionic (carrying no net charge).
- **Aluminium polymers,** such as poly-aluminium chloride that give rapid flocculation, efficient removal of organics and less alum under certain conditions, but at a higher cost.
- **Activated silica** is sometimes used as a flocculant together with alum as coagulant.
- **Bentonite and/or kaolin** are sometimes added to water when the water to be flocculated contains too few particles for effective flocculation.

References:
DWAF (2002). Quality of domestic water supplies. Vol. 4: Treatment Guide. WRC No. TT 181/02, pp. 21 to 22.

"Using a world first technique, CSIRO has found convincing evidence that the use of alum - aluminium sulphate - to treat drinking water is safe.
"We found that the aluminium we get from alum-treated drinking water is such an insignificant amount we don't need to worry. Only 1-2% of our daily intake of aluminium comes from water and of this, only the barest trace is absorbed. Much of the aluminium that is absorbed is then excreted in urine," CSIRO scientist Dr Jenny Stauber says.
The results have significance for water authorities around the world who use alum to clarify drinking water as part of the water treatment process. Alum is later filtered from the water, but a small fraction dissolves and is not removed.

The cause of Alzheimer's disease is subject to international research. A variety of possible causes have been considered however no link between aluminium intake and Alzheimer's has been established. However some conflicting evidence in earlier studies suggested that aluminium that is left in treated drinking water may be more readily taken up by the body than aluminium from other sources.
"Aluminium is the Earth's third most common element and occurs naturally in food and water. Most of the aluminium we consume in our food and drinking water is not absorbed and goes straight through our bodies to be excreted in faeces. What we were interested in was the trace that is absorbed into our blood," Dr Stauber says.
"If aluminium from water were to significantly increase the total amount of aluminium in the human body, it would have to be in a form that is much more easily absorbed into our bloodstream (i.e. more bioavailable) than aluminium in food (which has low bioavailability). This is because a greater proportion of our daily intake of aluminium comes from food," Dr Stauber says.
"We were able to calculate that aluminium from alum-treated drinking water would contribute less than 1 per cent to our body burden of aluminium over a lifetime. However the good news is that a related study on food shows that even what we get from food is well within the safe limits determined by the World Health Organisation," Dr Stauber says."

CSIRO, the Commonwealth Scientific and Industrial Research Organisation. Media Release: Ref 98/258. 2 November 1998