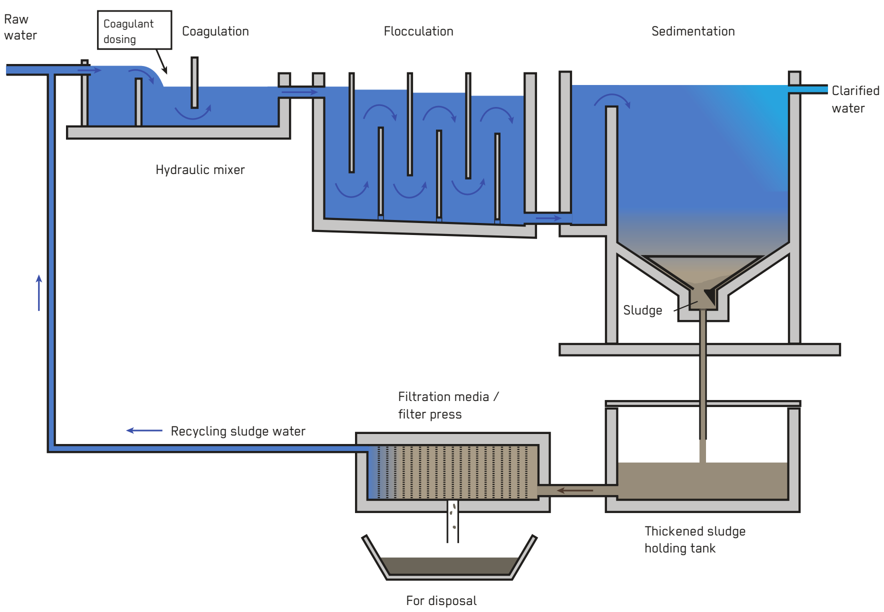
(Assisted) Sedimentation

Response Phase	Application Level	Management Level	Objectives / Key Features
** Acute Response ** Stabilisation ** Recovery	** Household ** Neighbourhood ** City	** Household ** Shared ** Public	Turbidity removal, pre-treatment, coagulation and sedimentation
Local Availability	**Technical Complexity**	**Maturity Level**	
*** High	** Medium	*** High	



Sedimentation is a pre-treatment step used to remove suspended solids from water with varying levels of turbidity (or 'muddiness') and may involve the addition of chemicals to accelerate the process. It can be used prior to a final treatment step, such as Microfiltration (T.3), Chlorination (T.6) or Nanofiltration/Reverse Osmosis (T.15). Sedimentation can be used in all phases of an emergency.

Sedimentation is a process in which physical particles in water settle out over time. Gravity alone may be sufficient for this process, though for raw water containing fine colloidal matter that only slowly settles or does not settle at all, the addition of chemicals is required to speed up the process. This is known as both 'Assisted Sedimentation' (since the natural Sedimentation process is accelerated) or as 'coagulation and flocculation'. Here, the chemical coagulant added to the water destabilises the electrostatic charges of colloids so they come together to form larger particles (flocculation) through mechanical mixing. These heavier particles then settle out faster (sedimentation). (Assisted) Sedimentation can be done at all scales, from large treatment plants to the household level.

Design Considerations: Sedimentation as a pre-treatment aims at reducing turbidity to a level suitable for subsequent treatment processes. In most cases, this is Chlorination **(T.6)**, so a turbidity of less than 5 NTU is required. During Sedimentation, pathogen concentrations are somewhat reduced (as they tend to be associated with solid particles in the water), and there is considerable improvement in colour, taste, odour and levels of metals such as iron, manganese, fluoride and arsenic. The first stage is to decide whether a coagulant is required, which can be determined using a settling test in a bottle. A rule of thumb is to settle water for one hour (or whatever the proposed detention time would be in the Sedimentation tank) and check if the particles have settled. If the top 80 % of the bottle has water that is clarified enough for the next treatment process, then natural Sedimentation will be sufficient.
Where natural Sedimentation is too slow, the process can be accelerated by the addition of a chemical coagulant. Aluminium-based coagulants (such as aluminium sulphate) are effective over a fairly narrow pH range of around 6 to 8. Outside of this range, more coagulant must

be added, which increases the cost as well as the aluminium concentration in treated water, creating a health hazard. Therefore, initially adjusting the pH of the raw water may be needed to reduce the required coagulant amount. Alternatively, iron-based coagulants are effective over a wider pH range, but are less frequently available and may cause staining. Both of these coagulants reduce the pH of treated water, and where this drops to < 6.5, post-treatment pH adjustment might be needed to reduce the risk of corrosion if metal pipes and tanks are subsequently used. Organic coagulants also exist (e.g. Moringa seeds) that have a wide effective pH range and have been used both at the household level **(see H.8)** and on a larger scale. The actual optimal dose for any raw water cannot be calculated in theory so is instead determined experimentally by a 'jar test' using a series of beakers containing an increasing dose of coagulant. Jar tests need to be redone when turbidity changes seasonally.
The abstraction method can help to ensure a relatively stable turbidity by pumping water from the same place and from near the surface (e.g. using a floating intake, **see I.3**). Coagulants should be dosed at a point of turbulent flow due to the rapid chemical reaction and at a rate proportional to the water flow rate. In emergencies, dosing is often performed using a variable-area flow meter, valve and tee on the suction side of a pump, though other methods also exist (e.g. electric-driven dosing pump). Flocculation requires slow stirring (< 1 m/s to prevent floc break up), although in emergencies, this is often done by discharging pumped water into a tank at an angle to stimulate a slow circular flow.
Larger Sedimentation basins are sized based on design guidelines for detention time and surface loading rate. When little land area is available, inclined plates or tubes can be installed within the Sedimentation basin to reduce the area needed by over 75 %. In emergencies, Assisted Sedimentation often occurs in the same tank as the flocculation. Here it can be difficult to achieve perfect results, so a good option is to pump water through rapid sand pressure filters to trap the remaining flocs **(see T.5)** prior to final treatment. Another option that saves space and equipment in an emergency is an upflow clarifier that requires only one tank. In this design, flocs accumulate as a floating blanket near the top of the tank.

Materials: Materials will vary depending on whether chemicals are required. In addition to the Sedimentation tank, materials may include a pump, a coagulant dosing mechanism, flocculation tank, sludge disposal mechanism, as well as chemicals for coagulation and possibly pH adjustment (acids or alkalis).

Applicability: This treatment process is suitable for all phases of an emergency. In the acute response, it can be started quickly for bulk water treatment. At a household level in emergencies, flocculant-disinfectant sachets **(see H.8)** may prove a good option for immediate distribution to dispersed populations where bulk water treatment might not be possible. In the longer term, communities can be educated about the benefits of the household 3-pot system for maximising natural Sedimentation. Larger-scale Sedimentation units are possible in the recovery phase once there is time for adequate design and piloting. However, consideration should also be given to possible alternative pre-treatment options such as Roughing Filtration **(T.1)** to reduce cost, ongoing reliance on chemicals and sludge removal issues.

Operation and Maintenance: O & M requirements are significant and require well-trained operators. Tasks include monitoring turbidity before and after treatment, regular jar testing, modifying dosing, draining and cleaning tanks, disposing of sludge, and storing and mixing chemicals. General plant maintenance will also be needed (e.g. pumps, mixers, valves).

Health and Safety: As a pre-treatment process, further disinfection is always required. Sludge should be disposed of safely (e.g. in landfills, sewers or with wastewater plant sludge), although this can be a challenge in an emergency. Where aluminium sulphate is used as coagulant, the aluminium concentration in clarified water cannot exceed 0.2 mg/L for health reasons. If problematic, this can be reduced by adjusting the pH of the raw water or by filtering through a Rapid Sand Filter **(T.2)**. Chemicals must be treated with care since they are corrosive.

Costs: Capital and ongoing costs vary widely according to the exact treatment set-up, required flow rate and country location, though in general, increasing the plant size decreases the cost per m^3 of water produced.

Social and Environmental Considerations: (Assisted) Sedimentation is generally well accepted by consumers and institutions, as water turbidity is visibly improved. Sludge produced during coagulation can cause environmental risks if disposed of near groundwater sources.

Strengths and Weaknesses:

(+) Good method for treating highly turbid water with high concentrations of colloidal matter
(+) Can be used to start bulk treatment quickly in an emergency
(+) Required materials are widely available

(−) Requires a lot of land space
(−) Requires skilled operators for dosage/chemical handling
(−) Requires a continuous supply of coagulant and power

→ **References and further reading material for this technology can be found on page 217**