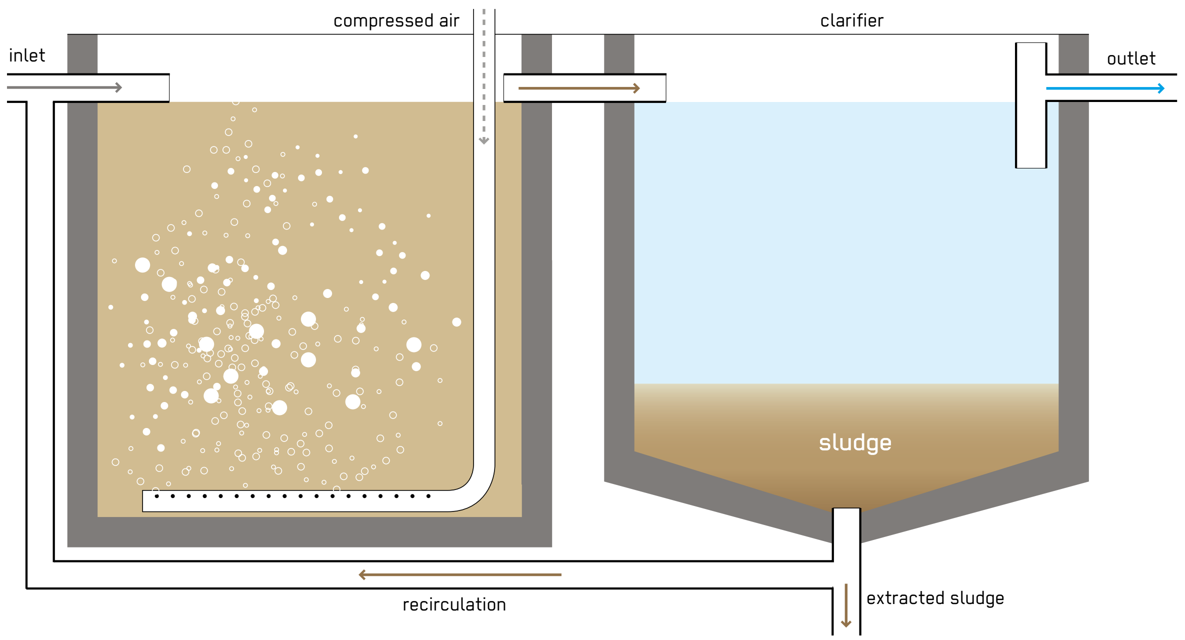
Activated Sludge

Phase of Emergency	Application Level / Scale	Management Level	Objectives / Key Features
Acute Response * Stabilisation ** Recovery	Household * Neighbourhood ** City	Household Shared ** Public	BOD reduction, Nitrification and nutrient removal, Pathogen reduction
Space Required	**Technical Complexity**	**Inputs**	**Outputs**
** Medium	*** High	● Blackwater, ● Greywater, ● Effluent	● Effluent, ● Sludge



An Activated Sludge process refers to a multi-chamber reactor unit that makes use of highly concentrated microorganisms to degrade organics and remove nutrients from wastewater to produce a high-quality effluent. To maintain aerobic conditions and to keep Activated Sludge suspended, a continuous and well-timed supply of oxygen is required.

Different configurations can be employed to ensure wastewater is mixed and aerated. Aeration and mixing can be provided by pumping air or oxygen into the tank or by using surface aerators. Microorganisms oxidise organic carbon in wastewater to produce new cells, carbon dioxide and water. Aerobic bacteria are the most common organisms, but facultative bacteria along with higher organisms can be present. The exact composition depends on the reactor design, the environment, and wastewater characteristics. Several weeks are needed to establish the microorganisms required for a stable biological process.

The flocs (agglomerations of sludge particles), which form in the aerated tank, are removed in the secondary clarifier by gravity settling. Excess sludge is partially removed and partially recycled for the biological process. In an immersed membrane bioreactor (IMBR), the activated sludge reactor is combined with a micro- or ultrafiltration membrane unit. By passing the membrane, treated water gets separated from sludge. The system can be set up as a pre-assembled solution or can be constructed on-site. The IMBR is an efficient compact technology for municipal (and industrial) wastewater treatment. The major drawback impeding wider application is membrane fouling, which significantly reduces membrane performance and lifespan, resulting in a significant increase in operation and maintenance (O & M) costs.

Design Considerations: Activated Sludge processes usually require primary treatment that removes settleable solids and are sometimes followed by a final polishing step **(POST)**. The biological processes are effective at removing soluble, colloidal and particulate materials. The reactor can be designed for biological nitrification and denitrification, as well as for phosphorus removal. The design must be based on an accurate estimation of the wastewater composition and volume. Treatment efficiency can be severely compromised if the plant is under- or over-dimensioned. Depending on the temperature, the solids retention time in the reactor ranges from 3–5 days for biochemical oxygen demand (BOD) removal, to 3–18 days for nitrification. Excess sludge requires treatment to reduce its water and organic content and to obtain a stabilised product suitable for reuse or final disposal. To achieve specific effluent goals for BOD, nitrogen and phosphorus, different adaptations and modifications can be made, which include sequencing batch reactors, oxidation ditches, extended aeration, moving beds and membrane bioreactors.

Materials: Usually the Activated Sludge reactor is made of plastic or concrete. The aerators consist of stainless steel or plastic and a membrane of rubber seal. For the potential subsequent membrane process either ceramic, polymeric, or composite membranes can be used. The material used has an impact on fouling propensity in IMBRs. Different pre-fabricated models are available.

Applicability: Activated Sludge treatment can be an appropriate solution in the stabilisation and recovery phases of a humanitarian emergency, particularly in more densely populated urban areas or larger camp contexts where water-based systems are preferred. It is a centralised treatment that needs well-trained staff, constant electricity and a highly developed management system. Because of economies of scale and less fluctuating influent characteristics, it is more effective for treatment of larger volumes. Activated Sludge processes are appropriate in almost every climate, but treatment capacity is reduced in colder environments. Given that the system is well operated the quality of the treated water can be suitable for reuse.

Operation and Maintenance: Trained technical staff are required for maintenance and trouble-shooting. Mechanical equipment (mixers, aerators and pumps) must be constantly maintained. Influent and effluent must be continuously monitored and control parameters adjusted, if necessary, to avoid abnormalities like kill-off of active biomass or development of detrimental organisms (e.g. filamentous bacteria). Access to the facility should only be allowed to trained personnel.

Health and Safety: Due to the space required and odour produced, Activated Sludge facilities are generally located on the periphery of densely populated areas. Although the effluent produced is of high quality, it still poses a public health risk and should not be directly handled. In the excess sludge, pathogens are substantially reduced but not eliminated. IMBR performance and treatment quality can be improved depending on the membrane used. Involved personnel need to be equipped with proper personal protective equipment.

Costs: Capital costs for Activated Sludge facilities are high. Costs may vary depending on availability and costs of construction material and electricity. Due to the requirements of skilled staff, continuous monitoring tasks and constant energy requirements the operational costs are high and need to be reflected in the total cost calculations.

Social Considerations: The installation of an activated sludge reactor should be carried out in areas where there is knowledge and experience with this technology and skilled personnel are available. Depending on the cultural context and existing regulations there may be barriers to re-using processed water.

Strengths and Weaknesses:

(+) Resistant to sudden loads of organic material or flow increases
(+) High reduction of BOD and pathogens (up to 99 %)
(+) High nutrient removal possible
(+) Can be modified to meet specific discharge limits

(−) High energy consumption requiring constant source of electricity
(−) High capital and operating costs
(−) Requires expert design and O & M by skilled personnel and not all parts and materials may be locally available
(−) Prone to complicated chemical and microbiological problems

→ **References and further reading material for this technology can be found on page 194**