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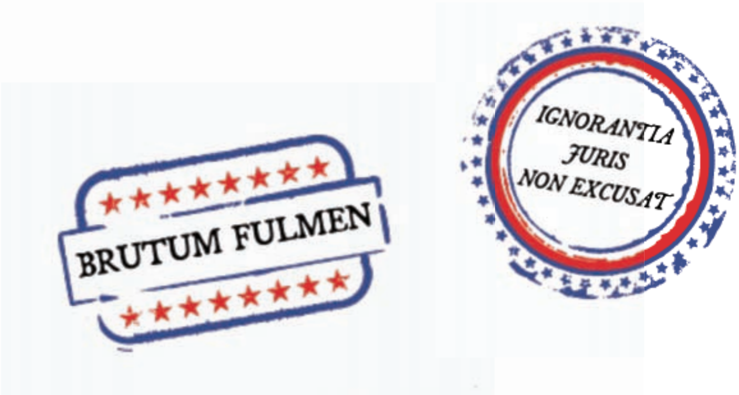

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Indian Standard

REQUIREMENTS FOR SLOW SAND FILTERS

PART 1 GENERAL GUIDELINES

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REQUIREMENTS FOR SLOW SAND FILTERS

PART 1 GENERAL GUIDELINES

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Indian Standard

REQUIREMENTS FOR SLOW SAND FILTERS

PART 1 GENERAL GUIDELINES

0. FOREWORD

0.1 This Indian Standard (Part 1) was adopted by the Indian Standards Institution on 30 August 1985, after the draft finalized by the Public Health Engineering Equipment Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 A safe and convenient water supply is a paramount importance to human health and well being of a society as a whole. Although the field of water treatment offers a variety of technological choices, only a few of them fully meet the specific requirement of rural areas. One such method is slow sand filtration — a simple, efficient and reliable technique for the treatment of water. In the construction of the plant, locally available material is generally used and the skills for construction, operation and maintenance are usually available locally or easily acquired. This standard is intended to give guidance for the application of slow sand filtration for biological purification of surface water polluted by human or animal excreta. Ground water treatment by means of slow sand filtration is not covered in the standard.

0.3 In formulating this standard assistance has been derived from the following:

a) L. Huisman and W. E. Wood: Slow Sand Filtration, 1974. World Health Organization, Geneva.

b) Technical paper No. 11. December 1978 WHO International Reference Centre for Community Supply and Sanitation. World Health Organization, Geneva.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard (Part 1) covers general principle, performance, applicability and limitations of slow sand filters for water treatment.

2. DESCRIPTION OF BASIC ELEMENTS

2.1 Basically, a slow sand filtration unit consists of a water tight box, containing a supernatant raw water layer, a bed of filter medium, a system of underdrains and a set of filter regulation and control devices. A typical illustration of basic elements of slow sand filter is given in Fig. 1.

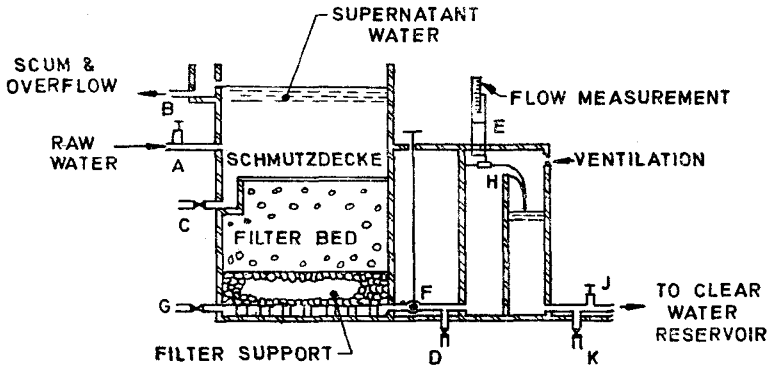

FIG. 1 BASIC ELEMENTS OF A SLOW SAND FILTER

2.1.1 *Supernatant Water Layer* — The supernatant water layer provides the driving force for raw water to pass through the bed of filter medium and creates a detention time of several hours for the raw water to be treated, during which period particle may settle and/or agglomerate or be subjected to other physical or (bio) chemical processes.

2.1.2 *Bed of Filter Medium* — In principle, the filter medium may consist of any porous, stable material. But in domestic water supply practice granular sand which is widely available in nature, inert, cheap and durable is commonly used. The sand should be free from clay, loam and organic matter.

2.1.3 *Underdrain System* — The underdrain system serves two purposes; it provides an unobstructed passage for the filtered water and supports the bed of filter medium. It usually consists of a main and lateral drains made of perforated or non-jointed pipes, concrete blocks, or well-burnt bricks. The underdrains are covered by layers of graded gravel. The gravel laid with large sized pieces at the bottom and progressively reducing in size to the top, prevents sand grains from entering into the drainage system.

2.1.4 *Filter Regulation and Control Devices* — The important filter regulation and control devices are listed below (*see* Fig. 1).

A — Raw water delivery valve with or without a level control mechanism.

B — Device for drainage of overflow and scum.

C — Valve for drainage of supernatant water prior to filter cleaning.

D — Valve for drainage of water from filter bed.

E — Calibrated flow measuring device for filtered water.

F — Filtered water outlet valve for regulation the filteration rate.

G — Interconnection valve for backfilling with clean water after filter cleanning.

H — Outlet weir with its sill located slightly above the maximum level of sand in the filter bed. This weir prevents the occurrence of negative head in the filter and by allowing a free fall facilitates the operation of filters independant of fluctuations of water level in clear water reservoir. The weir also helps to increase the dissolved oxygen content of filtered water.

J — Delivery of treated water to the clear water storage reservoir.

K — Delivery of water to waste.

3. PRINCIPLE OF PURIFICATION OF WATER

3.0 During the passage of raw water through the bed of filter medium the water quality improves considerably by reduction in the number of micro-organism (bacteria-viruses, cysts, etc) by removal of suspended and colloidal material and by changes in its chemical composition. A newly commissioned filter is run for a few weeks to mature when a thin, sticky layer called the 'Schmutzdecke' is formed on the filter bed and around the sand grains in the bed. The surface layer of Schmutzdecke consists of a variety of biologically active micro-organisms which breakdown organic matter and convert it into simple, harmless substances. A great deal of suspended inorganic matter is retained in the bed and a clear, safe water is produced.

3.1 Process of Purification — The purification starts in the supernatant raw water layer where large particles will settle into the filter bed and smaller particles may agglomorate to settleable flocs due to physical or bio (chemical) interactions. Under the influence of sunlight, algae will grow, producing oxygen which helps the biological processes. The number of bacteria will decrease and there will be reduction of organic matter due to bio-chemical oxidation.

Major part of the removal of impurities and considerable improvement of the physical, chemical and bacteriological quality of raw water takes place in the filter bed and especially in the Schmutzdecke. In this top layer abound micro-organisms such as algae, plankton, diatoms and bacteria, which through their tremendous biological activity, break down organic matter.

As the water passes through the bed it is constantly changing direction so that particles carried by the water come into contact with the filter grains by various transport mechanisms. The grains become covered with a sticky layer of mainly organic material which in turn absorbs these particles by various attachment mechanisms. At the same time the active micro-organisms (bacteria, protozoa, bacteriophages) in the sticky layer around the grain feed on the impurities caught as well as on each other. In this way, degradable organic matter, including bacteria and viruses of faecal origin, is gradually broken down and converted into water, carbon dioxide and harmless inorganic salts. The life-filled zone where these purification mechanisms takes place extends to about 0·4-0·5 m down from the surface of the filter bed, but it gradually decreases in activity downwards as the water is purified and contains less organic matter and nutrients. At greater depth in the filter bed the products of the biological processes are further removed by physical processes (adsorption) and chemical action (oxidation).

3.2 The transport, attachment and purification mechanisms described will only function effectively if a sufficient detention time in the filter bed is allowed for the water to be treated. Especially, when slow sand filtration is the main treatment processes, the rate of filtration should be kept low (0·1 and 0·2 m/h) or 0·1-0·2 m^3/m^2 bed area per hour. Another important parameter for the purification process is the oxygen content of water. The activity of the biomass will decrease considerably if the oxygen content of water into the filter medium falls below 0·5 mg/*l*. If the anaerobic conditions occur, obnoxious impurities may be released to the water by the biomass. Such occurrences may be prevented by aeration of the raw water pre-sedimentation of the raw water or recycling part of the aerated effluent to the supernatant water reservoir. For additional aeration of filtered water, the outlet weir chamber should be provided with suitable ventilation.

4. PERFORMANCE OF SLOW SAND FILTER

4.1 The effect of the purification process on water quality depends on many factors, such as raw water quality, rate of filtration, grain size of the filter medium, the temperature and oxygen content of the water. For normal operational conditions, the average performance of slow sand filters with regard to the removal of certain impurities is given in Table 1.

TABLE 1 PERFORMANCE OF SLOW SAND FILTERS

PARAMETER	PURIFICATION EFFECT
Organic matter	Slow sand filters produce a clear effluent, virtually free from organic matter
Bacteria	Between 99 and 99·99 percent of the pathogenic bacteria may be removed; cercariae of schistosoma, cysts and ova are removed to an even higher degree; E. Coli are reduced by 99-99·9 percent
Viruses	In a mature slow sand filter, viruses are virtually completely removed
Colour	Colour is significantly reduced
Turbidity	Raw water turbidities of 100-200 NTU can be tolerated for a few days only; a turbidity more than 50 NTU is acceptable only for a few weeks; preferably 10 NTU; for a properly designed and operated filter the effluent turbidity will be less than 1 NTU.

5. APPLICABILITY AND LIMITATION OF SLOW SAND FILTERS

5.1 Slow sand filtration is an efficient method for removal of organic matter and pathogenic organisms. It is, therefore, a particularly appropriate treatment method for surface waters containing objectionable quantities of such impurities. If raw water contains high content of suspended matter (inorganic turbidity), pre-treatment unit should be installed to prevent rapid clogging of the filter.

5.2 Slow sand filters require relatively large area and a large quantity of filter medium. They are usually cleaned by mannual labour. They are cost effective for small and medium communities up to about 8·0 MLD plant capacity where cost of land and labour is relatively inexpensive.

5.3 Sudden changes in raw water quality and freezing weather conditions may temporarily upset the performance of biological filters. Presence of algae may improve the quality of Schmutzdecke, but too high an algae content of certain species may result in rapid clogging and short filter runs. Because of their simplicity in construction, operation and maintenance, they are ideally suited for rural water supplies and where skilled labour and supervision are difficult to provide.

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