IS 12742 : 1989
(Reaffirmed 1995)

भारतीय मानक

पीने के लिए पानी का निर्फ्लोराइडीकरण (रसायनिक उपचार पद्धति) की मार्गदर्शिका

Indian Standard

GUIDE FOR DEFLUORIDATION OF WATER FOR DRINKING PURPOSES (CHEMICAL TREATMENT METHOD)

(First Reprint SEPTEMBER 1995)

UDC 628·1·033 : 628·162·094·4

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February 1990 Price Group 4

Water Sectional Committee, CDC 26

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 31 October 1989, after the draft finalized by the Water Sectional Committee had been approved by the Chemical Division Council.

All waters available in nature are contaminated, in one way or the other, and invariably require treatment before supply to users. In the perspective of the concern of the Government of India to ensure supply of safe quality potable water to all citizens, more so the rural communities, added significance attaches to the techniques of water treatment of removal of various contaminants including fluorides. Of course, the fluorides are beneficial if present in concentration of 0·6 to 1·2 mg/l, but are hazardous if their concentration is in excess of 1·5 mg/l. There are two methods of treatment for fluoride removal, namely, chemical treatment and ion exchange process. Chemical treatment method covered herein is based on Nalgonda technique.

Indian Standard

GUIDE FOR DEFLUORIDATION OF WATER FOR DRINKING PURPOSES (CHEMICAL TREATMENT METHOD)

1 SCOPE

1.1 This standard prescribes guidelines for defluoridation of water for drinking purposes by chemical treatment method.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
IS 7022 (Part 1) : 1973	Glossary of terms relating to water, sewage and industrial effluents, Part 1
IS 7022 (Part 2) : 1979	Glossary of terms relating to water, sewage and industrial effluents, Part 2

3 TERMINOLOGY

3.1 For the purpose of this standard, definitions given in IS 7022 (Part 1) : 1973 and IS : 7022 (Part 2) : 1979 shall apply.

4 MECHANISM OF DEFLUORIDATION

4.1 The chemical method for the removal of excessive fluorides at domestic and community levels involves precipitation by aluminium salts. This process is recommended when fluoride content of raw water ranges from 1·5 to 20 mg/1. Aluminium in the alum salts when added to water is hydrolized in the presence of natural alkalinity. The extent of hydrolysis is dependent on *p*H. The products are called polyhydroxy alumino complexes. These are more effective in fluoride removal.

4.2 The chemical methoa (Nalgonda technique) is a combination of several unit operations and processes incorporatıng rapid mixing, chemical interaction, flocculation, sedimentation, filtration disinfection and sludge concentration to recover water and aluminium salts.

4.2.1 *Rapid Mix*

Provides thorough mixing of alkali, aluminium salts and bleaching powder with the water. The chemicals are added as shown in flow diagram just when the water enters the system.

4.2.2 *Flocculation*

Flocculators provide subsequent gentle agitation before entry to the sedimentation tank. The flocculation period permits close contact between the fluoride in water and polymeric species formed in the system. The interaction between fluoride and aluminium species attains equilibrium.

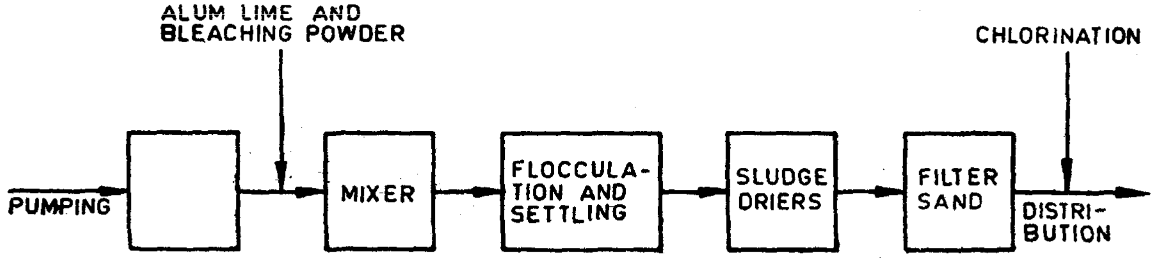
NOTES

1 Addition of lime ensure adequate alkalinity for effective hydrolysis of aluminium salts, so that residual aluminium does not remain in the treated water.

2 Simultaneous disinfection is achieved with bleaching powder which also keeps the system free from undesirable biological growths.

4.2.3 *Sedimentation*

Permits settleable floc loaded with fluorides, turbidity, bacteria, and other impurities to be deposited and thus reduce concentration of suspended solıds that must be removed by filters.



4.2.4 *Filtration*

Treated water sedimentation shall be filtered by rapid gravity sand filter for removal of escaping flocs. This facilitates further removal of fluorides and bacteria.

4.2.5 *Disinfection and Distribution*

The filtered water collected in the storage water tank is rechlorinated with bleaching powder and distributed according to the community water supply practice.

5 RECOMMENDED DESIGN CONSIDERATIONS

5.1 Fill and Draw Type Vertical Unit

Site specific data especially with regard to existing facilities, structure like overhead tanks, or sump wells and mode of water distribution will override the design consideration. The unit comprises a cylindrical tank of 10 m^3 capacity with dished bottom, and equipped with inlet, outlet and sludge drain. The stability of cylindrical tank has to be ensured. Each tank is fitted with an agitator assembly consisting of : (a) three phase electric motor, and (b) gear box with reduction ratio 60 : 1 to attain an output speed of 20 to 25 rpm, complete with downward shaft to hold the agitator paddles. The agitator is fixed to the bottom of the vessel by sturdy, suitable stainless steel supporting bushings. The scheme comprises tanks of 10 m^3 capacity each, a sump well and an overhead reservior. A system with two units in parallel for treating water for a population of 1 500 at the rate of 40 lpcd is shown in Fig. 1. Raw water is pumped into the units and treated by chemical method. The treated water collected in a sump is pumped to an overhead tank, from where the water is supplied through stand posts.

5.2 Hand Pump Attachable Defluoridation Unit

5.2.1 The hand pump attachable defluoridation unit shall comprise:

a) *Raw water and chemical feed system comprising:*

1) continuous feed cylindrical tank with syphon system and connected to the hand pump;

2) alum solution dosing cylindrical tank attached to syphon system;

3) chemical feed device (Venturi system) for proportional dosing for alum solution to raw water from hand pump; and

4) PVC pipe water distribution system.

b) Cylindrical defluoridation unit of 18 m (minimum) diameter and 1 m height consisting of the following chambers:

1) *Flocculater* — 30 cm pipe semi-circular chambers of 65 cm depth loaded with 4 to 5 cm size gravel/stone bed;

2) *Sedimetation chambers* — 10 cm semi-circular chambers with detachable lid and its bottom slipping sludge scour;

3) *Filter chambers* — 50 cm semi-circular chambers with detachable lid and false bottom with 0·5 cm orifice 3 cm centre to centre. The filter media shall comprise the following:

i) *Sand* — 0·8 to 1 mm effective size and 20 cm in depth.

ii) *Supporting gravel* — 0·6 to 2 cm size gravel and 10 cm in depth.

c) Inter-connection piping, walls and other fixtures:

1) Connecting hand pump to raw water feed tank

2) Inter-connection between alum tank and feed system

3) The connection of hand pump spout with filter back wash plant.

d) *Concrete platform* — ground level; 2·5 m dia.

e) Soak pit with drain water channel from defluoridation unit platform.

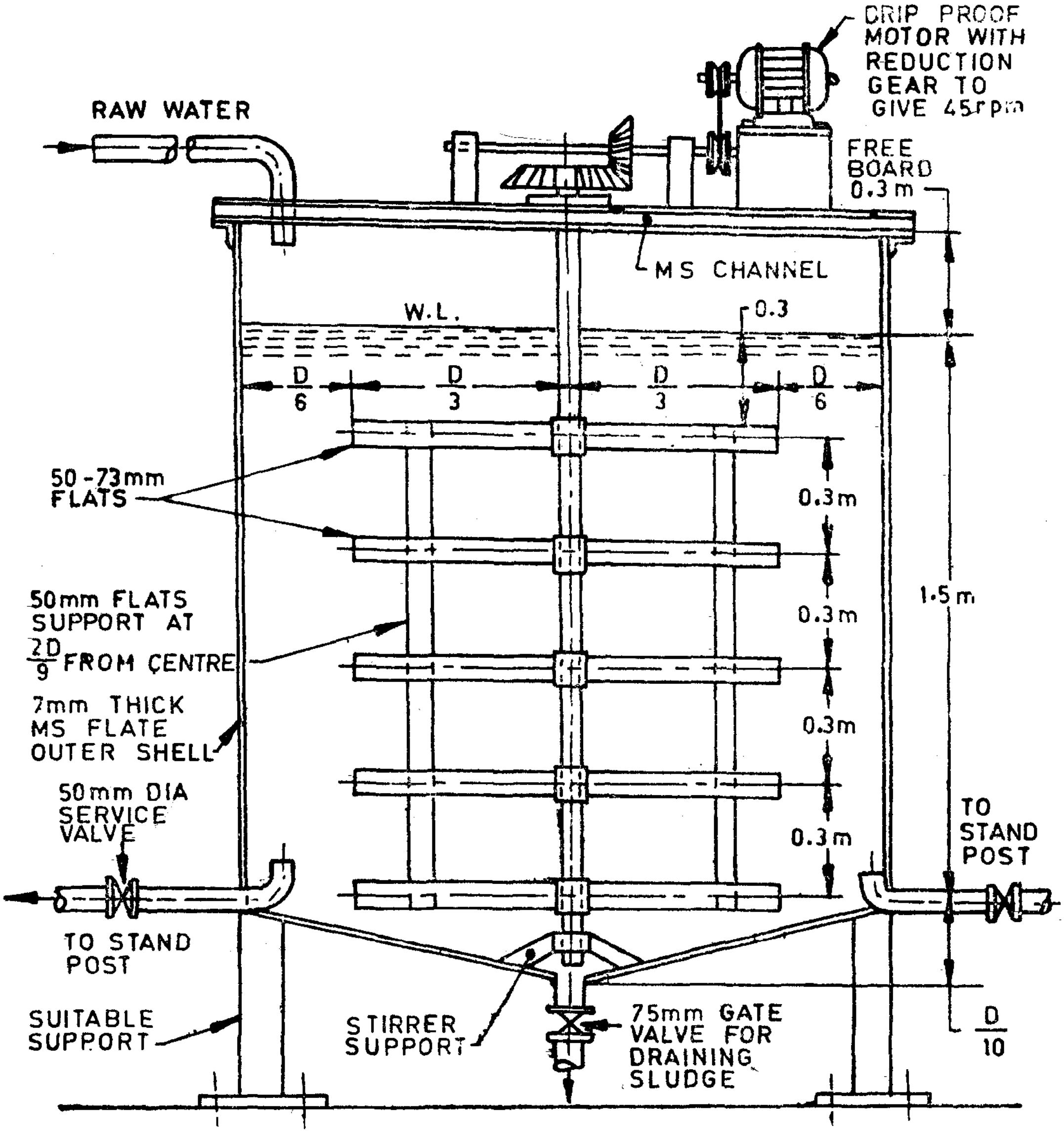
5.2.2 Pedestal with 3 steps and platform of 1 m width for operation of hand pump shall be constructed. The delivery tap of the pump shall be 1·8 m above ground level.

5.2.3 The alum tank and detachable lid shall be painted with anti-corrosive paint from outside and inside. The main body of the unit shall also be painted with anticorrosive paint from outside the unit.

5.3 Continuous Plant Operation

5.3.1 The treatment plant units are designed on the following considerations:

a) The treatment plant capacities have been worked out considering the net daily requirement (such as for a population of 500 persons with the supply rate of 70 lpcd — the capacity would come to 35 m^3/d) and additional ten percent extra (to cover clarifier bleed losses, filter back washings, etc. which together amounts to about 10 percent of the net requirement).



D = Diameter of plant

FIG. 1 FILL AND DRAW TYPE DEFLUORIDATION PLANT BASIS : 40 lpcd DOMESTIC WATER (FOR POPULATION UP TO 200)

b) Frequent power shut downs are common in villages, hence raw water pumping hours are assumed to be 2 hours in the morning and 2 hours in the afternoon. During these 4 hours period, total daily requirements of water are to be pumped to raw water elevated storage tank.

The treatment plant has been designed to operate under gravity system from raw water storage tank and raw water pumping starts simultaneously. This has been planned so that the effective storage capacity for raw water storage is proportionately increased.

The total daily requirement of raw water is pumped in 4 hours period that is 2 hours in the morning and 2 hours in the afternoon. The net effective storage needed for raw water to operate the plant under gravity is worked out.

After the pumps stop in the morning, the stored raw water from storage tank is fed to treatment plant for next 6 hours, when again the raw water pumping resumes for 2 hours and the cycle is continuous.

c) The flash mix unit, flocculator, settling tank and filter units operate under gravity system.

d) The filtered water is stored in 'filtered water sump'. The supply hours are also assumed to be the same as raw water pumping hours that is 2 hours supply in the morning and 2 hours supply in the afternoon.

e) In order to avoid cost for extra overhead service reservoir for filtered water, it is presumed that filtered water from the sump will be directly pumped in the distribution system.

An example has been worked out for a population of 500 persons to determine the total quantity of water to be supplied:

Rate of water supply	70 lpcd
Total daily net requirement	$70 \times 500 = 35\,000$ l $= 35$ m^3
Total gross requirement (Considering clarifier bleed plus filter washings)	$35 + 3{\cdot}5 = 38{\cdot}5$ m^3
Raw water pumping hours (2 hours in the morning, 2 hours in the afternoon)	4 hours (total)

During morning, 50 percent gross raw water (19·25 m^3) requirements is pumped to raw water storage tank (and balance 50 percent in the afternoon when power supply resumes). During the period of raw water pumping hours, average rate of raw water going to treatment plant will be 2·406 m^3/h and the balance quantity is stored.

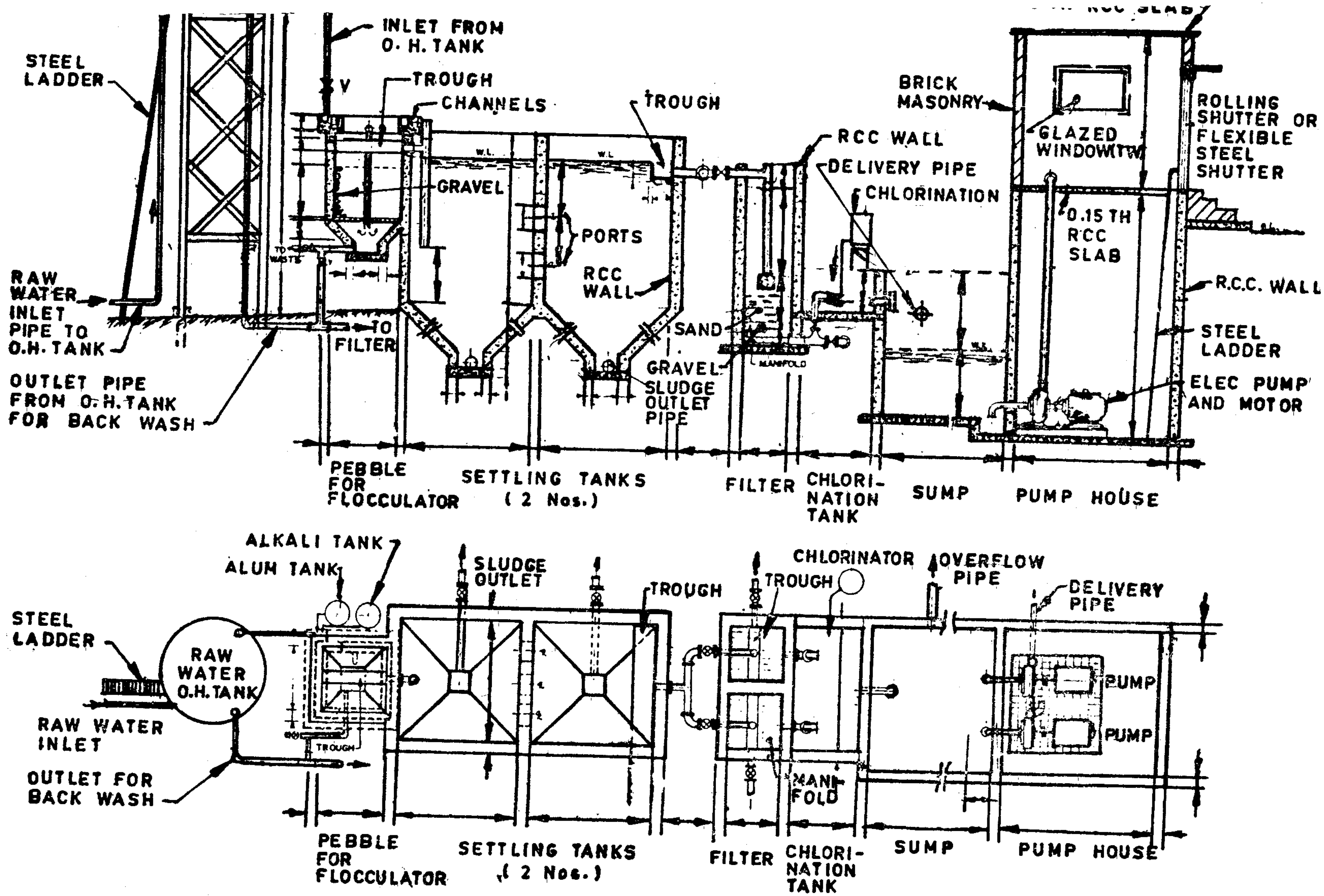
5.4 Specification of Units for Population of 500 to 5 000

Based on the design consideration given earlier, the sizes of all the units, namely, overhead tank, channel mixer, pebble bed flocculator, sedimentation tank, sand filter and underground treated storage water tank are given in Table 1. The sizes of the alum and lime tanks are given in Table 2. Table 3 indicates the alum requirements at various alkalinity and fluoride levels. Engineering details for water treatment are shown in Fig. 2 for population of 500, 1 000, 2 000 and 5 000.

5.5 Sludge-Water and Alum Recovery

The sedimentation tanks should be desludged on alternate days for five minutes. The total loss of water in desludging amounts to 1·0 — 1·5 percent of the total water quantity pumped into the treatment plant. This can be reduced considerably in community plants by making provision for sludge concentration well and drying beds. Water and alum is recovered from the sludge. The recovered alum can be used for purposes other than defluoridation. The fluoride (as F) in recovered alum is 8 to 10 g per kg alum.

The solids in sludge from sedimentation basins are 0·8 — 1·1 percent (w/v). By plain sedimentation, the concentration is increased to 2·5 — 3·1 percent (w/v) in 24 hours. Subsequent exposure of this concentrate of drying beds increases the solids to 28-30 percent (w/w).



NOTES

All dimensions are in metres

Scale—Not to scale

Foundation depends on soil condition legend

————Back Wash

- - - - Filtration

FIG. 2 LAYOUT PLAN

Table 1 Sizes of Various Units

(*Clause* 5.4)

(All dimensions in metres)

Treatment Units	Population							
	500		1 000		2 000		5 000	
	Num-bers	Dimensions	Num-bers	Dimensions	Num-bers	Dimensions	Num-bers	Dimensions
Raw water balancing tank	1	14.45 m^3	1	28.90 m^3	1	57.50 m^3	1	144.50 m^3
Diameter		3.00		4.00		5.00		7.00
Depth		2.00		2.30		2.95		3.80
Channel mixer with baffles	1		1		1		1	
Length		1.40		2.00		2.85		3.20
Width		1.40		2.00		2.85		3.20
Height		11.20		16.00		22.70		25.60
Flocculator pebble bed hopper	1		1		1		2	
Length		1.40		2.00		2.85		3.20
Width		1.40		2.00		2.85		3.20
Total height		1.80		1.80		1.80		1.80
Height of the conical portion		0.60		0.60		0.60		0.60
Settling tank hopper	2		2		2		2	
Length		2.30		3.10		3.60		5.70
Width		2.30		3.10		3.60		5.70
Total height		4.00		4.50		4.50		5.80
Height of the conical portion		1.0		1.5		1.5		2.8
Gravity filters	2		2		2		2	
Length		1.00		1.00		1.40		2.30
Width		1.00		1.00		1.40		2.30
Clear water sump	1		1		1		1	
Length		3.00		4.00		4.00		5.00
Width		3.00		5.00		10.00		10.00
Height		3.00		3.00		3.00		3.00

Table 2 Chemical Dosing Tank Capacities

(*Clause* 5.4)

Population	Alum Tank		Lime Tank	
	Capacity in litres	Dosing Rate ml/min	Capacity in litres	Dosing Rate ml/min
500	100	210	10	21
1 000	200	420	20	42
2 000	400	840	40	84
5 000	1 000	2 100	100	210

Strength of solutions:

Alum	10% (w/v)
Lime	1% (w/v)

Table 3 Approximate Alum Dose (mg/1) Required to Obtain Permissive Limit (1 mg F/1) of Fluoride in Water at Various Alkalinity and Fluoride Levels

(*Clause* 5.4)

Test Water Fluoride, mg F/1	Test Water Alkalinity, mg $CaCO_3$/1							
	125	200	300	400	500	600	800	1 000
2	143	221	273	312	351	403	468	520
3	221	299	351	403	507	520	585	767
4	*	403	416	468	559	598	689	936
5	*	*	507	598	689	715	884	1 010
6	*	*	611	715	780	936	1 066	1 209
8	*	*	*	*	988	1 118	1 300	1 430
10	*	*	*	*	*	*	1 508	1 690

* To be treated after increasing the alkalinity with lime or sodium carbonate.