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Removal of Dissolved Salts and Toxic Substances from Water Using Desert Desalting Kit*

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Abstract. A portable desert desalting kit for converting natural brackish water or waters deliberately contaminated with certain toxic substances into potable water has been developed. The potable water is of acceptable standards laid down by WHO/ICMR.

Based on ion exchange resin, the kit consists of a desalting bag with filter and eight chemical packets. It requires 15 min to obtain potable water (450 ml from each chemical packet) from brackish water containing dissolved solids upto 7000 mg/l yielding in all 3.6 litres of potable water sufficient for a man to survive for a day.

1. Introduction

The analyses[1] of waters of Western Rajasthan indicate that over 90 percent waters are unfit for drinking in view of their dissolved solids content, considering normal standards[2] of drinking water i.e. total dissolved solids (TDS) as less than 500 mg/l. At present no indigenous field kit is available for desalting the brackish waters available in desert region for drinking requirements of troops. Sea water desalting kits, generally based on silver salt, are particularly designed for removing high salt content ranging from 30-35 g/l TDS and are uneconomical for desalting brackish waters due to their high cost.

A survey and assessment of toxic and health affecting substances in the waters of Western Rajasthan conducted by the authors[3] indicated the presence of fluoride and nitrate in all the water samples analysed. Some of the trace elements, if present in significant amounts in water, are health hazards. Further, a toxicant introduced in the water by a saboteur may also render it unfit for drinking. This paper describes the development of 'Desert Desalting Kit' and the results of its trials by the users.

The Desert Desalting Kit[4] (Fig. 1; 14 cm × 12 cm × 9 cm), weighing 650 g, consists of a container, desalting bag and eight chemical packets containing indigenously

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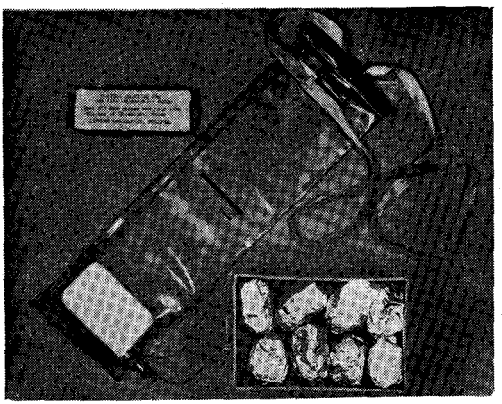

Figure 1. Desert desalting kit showing (a) desalting bag with filter in the centre; (b) eight chemical packets kept in the rectangular box below the bag, and (c) a chemical packet above the bag.

available ion exchange resins. It is required to shake 475 ml of brackish water (TDS, upto 7000 mg/l) with one packet of chemical in desalting bag for 10-15 min, subsequent to which 450 ml drinking water is obtained. 3.6 litres drinking water can be obtained using all the eight chemical packets.

2. Experimental

Cation exchange resins—*Agrion C-100, Tulsion-42, Zeo Karb-225* and *Doshion* and anion exchange resins-*De Acidite FF-IP* and *De Acidite H-IP* were exhaustively studied for their exchange capacities using natural brackish waters from Thar desert. A number of compositions of above resins were formulated and used for desalting the brackish waters ranging from 1000 to 10000 mg/l TDS. *Zeo Karb-225* is a cross linked polystyrene based, strongly acidic cation exchange resin with exchange capacity of 5 m. eq./g. dry resin. *De Acidite FF-IP* is a cross linked polystyrene based, strongly basic anion exchange resin with exchange capacity of 4 m. eq./g. dry resin. An ideal composition consisting of *Zeo Karb-225* (H^+ form) and *De Acidite FF-IP* (OH^- form) was selected. The desalting chemical consisting of aliquot amount (25 g) of this composition (*Zeo Karb-225* and *De Acidite FF-IP* in 1 : 2 ratio) activated charcoal (1 g) and required humidity (40-60%) was sealed in airtight packets made of aluminium foil with polythene lining.

The container was made of high density polythene and could be used for collecting desalted water required to be processed again when dissolved solids in the brackish water exceed 7000 mg/l limit. The desalting bag, consisting of a detachable filter, was made of non-toxic PVC (0.3 mm). The filter was made of polyacrylate and has stainless steel nozzle as outlet with a screw. It consists of three layers of filters to ensure the removal of all suspended particles from the desalted water.

Natural brackish waters from representative wells of the regions were selected for the study. The chemical constituents of these water samples and desalted waters are given in Table 1.

Table 1. Physico-chemical characteristics of brackish and desalted water

Sl. No.	Details	Brackish and desalted waters* (mg/l)				
		1	2	3	4**	5**
1.	TDS	1803 (22)	4873 (29)	7061 (788)	9680 (20)	11508 (305)
2.	*Cl*	637 (8)	1690 (10)	3605 (431)	5225 (7)	5856 (160)
3.	SO_4	73 (2)	945 (3)	499 (3)	276 (2)	985 (3)
4.	HCO_3	505 (6)	538 (7)	438 (48)	572 (7)	615 (23)
5.	*Ca*	72 (Traces)	36 (Traces)	200 (1)	112 (Traces)	408 (2)
6.	*Mg*	42 (1)	49 (1)	214 (2)	148 (1)	428 (3)
7.	*Na* + *K* (by difference)	474 (6)	1615 (9)	2105 (307)	3347 (6)	3216 (106)
8.	*p*H	8.0 (7.8)	7.7 (7.0)	7.6 (8.2)	8.0 (7.4)	7.6 (8.3)

* Details of desalted waters are shown in brackets (Input water 475 ml in each operation)

** Desalting was carried out in two operations. (Serial No. 2-7 expressed in ionic concentrations)

As, *Ba*, *Cd*, Cr^{+6}, *Pb*, *Ag*, *Se* and *CN* have not been found in natural waters of Rajasthan desert[5]. To test the efficacy of the kit for removing trace elements if present, the input brackish waters were contaminated with *Pb*, *As*, *Hg*, *Se*, *Cd*, and *CN* and treated with the kit. The detailed chemical analyses of contaminated and desalted waters are given in Table 2. The efficiency of the kit in removing fluoride and nitrate contents in natural brackish waters was also examined and the data are given in Table 2.

The exposure trials on the kit were conducted for one year by subjecting it to extreme desert environmental conditions in the field as well as in the laboratory to assess its shelf life.

3. Results and Discussion

The data shown in Table 1 indicate that the kit is effective in removing dissolved salts from the brackish waters. The quantity of the desalting chemical in the chemical packet (about 44 g) has been so selected that it desalts about 90 percent of the various water compositions available in the region to potable limit in a single operation. However, a second operation is required with another packet of the chemical for the waters having TDS above 7000 mg/l.

It is observed from Table 2 that the brackish waters contaminated with toxic ions of *Pb*, *As*, *Se*, *Cd*, *CN* and *Hg* on treatment yield desalted waters having dissolved solids and the trace elements within permissible limits. A laboratory sample containing all the trace elements in the input water with TDS, 1031 mg/l, also gave on treatment desalted water having toxic elements within permissible limits. Nitrate and fluoride present in the waters of this region are removed effectively as shown in Table 2.

The moisture content of the chemicals has to be adjusted within certain limits (optimum moisture around, 40 per cent) in order to retain their effectiveness for long

Table 2. Physico-chemical characteristic of brackish water contaminated with *Pb, As, Se, Hg, Cd, F, NO_3 & CN*

Sl. No.	Details	Brackish and desalted waters* (mg/l)					
		1	2	3	4	5	6
1.	TDS	3050 (26)	3068 (22)	3076 (23)	3119 (19)	3030 (26)	1031 (11)
2.	*Cl*	1013 (7)	1267 (8)	1283 (8)	1240 (6)	1033 (6)	477 (5)
3.	SO_4	20 (<3)	120 (<3)	115 (<3)	118 (<3)	—	—
4.	HCO_3	593 (7)	590 (6)	585 (5)	593 (7)	575 (7)	21 (3)
5.	NO_3	72 (5)	—	—	—	135 (7)	35 (1)
6.	*F*	—	—	—	25 (<1)	—	—
7.	*CN*	—	—	—	—	—	15 (<0.2)
8.	*Pb*	120 (<0.05)	—	—	—	—	20 (<0.05)
9.	*As*	—	50 (<0.05)	—	—	—	20 (<0.05)
10.	*Se*	—	—	50 (<0.01)	—	—	20 (<0.01)
11.	*Hg*	—	—	—	125 (<0.001)	—	20 (<0.001)
12.	*Cd*	—	—	—	—	125 (<0.01)	30 (<0.01)
13.	*Ca*	45 (1)	37 (1)	35 (1)	37 (1)	42 (1)	7 (Traces)
14.	*Mg*	20 (1)	29 (1)	29 (1)	29 (1)	24 (1)	6 (Traces)
15.	*Na + K* (by difference)	1167 (8)	975 (7)	979 (7)	952 (6)	1091 (8)	360 (4)
16.	*pH*	8.3 (7.0)	8.0 (6.9)	7.8 (7.0)	8.0 (6.8)	8.2 (7.1)	7.3 (6.8)

*Details of desalted waters are shown in brackets (Input water 475 ml in each operation)

Serial No. 2-15 expressed in ionic concentrations.

periods, Ten desalting kits with components were exposed to desert environmental conditions for one year and found to be unaffected. The efficiency of the chemicals, its moisture content and durability of the plastic materials used in the manufacture of container, bag and filter were also found unaffected after shelf life period of one year.

Five different user agencies carried out the trials on 50 kits. The trials were conducted under natural conditions at the water points in the Thar desert. The kit passed all the tests and has been accepted for introduction into Armed Forces.

References

1. Gopal, R., *et al.*, *Def. Sci J.*, **31**, (1981), 73–86.
2. 'Manual of standards of quality for drinking water supplies, Indian Council of Medical Research, Special Report Series No. **44** (1975), 22.
3. Gopal, R., *et al.*, 'Salinity and Toxicity of Brackish Waters of Western Rajasthan used for drinking' Report No. DL/TC/CHEM/75/1, (Defence laboratory, Jodhpur), 1975.
4. Singh, Y. P., *et al.*, 'Development of Desert Desalting Kit' Report No. DLJ/TC/CHEM/76/11, (Defence laboratory, Jodhpur), 1976.
5. Gopal, R., *et al.*, *Def. Sci. J.*, **31**, (1981), 105–108.