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A Novel Method of Obtaining Potable Water from Lonar Lake

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Diffusion controlled ionic migration, in a suitably optimized W-cell geometry, has given rise to formation of acidic and alkaline zones, separated by a neutral zone. Using this optimized W-cell, having internal diameter 15 mm and central height 20 cm, desalination of Lonar lake water samples at 400 V has been carried out. This method gives optimum yield of potable water with minimum consumption of electrical energy.

INTRODUCTION

The Lonar structure[1], variously described as a hollow, depression or crater, is situated about a kilometre south-west of the village of Lonar (19°58′45″ : 76°34′0″) in the Buldhana district of Maharashtra state. The circular feature measuring 2000 m across and about 135 m in depth, has a shallow saline lake at its bottom, is also roughly circular and measures abut 1200 m across. Maximum depth of brine is about 5.5 m and the lake bottom appears to be fairly even. The lake silt is up to 30 m thick.

Utilization of constructions in electrolytic cells for molecular dissociation is becoming a promising technique and has now acquired the name SESER (Source of Electrons in Selected Energy Range). This technique has been employed in liquid solutions by Heller *et al.*[2] In an article "Non-Faradic Electrolysis: Main Features", Palit[3] has reported several anomalies observed by him during non glow electrolysis. Besides these anomalies Palit[4] and Palit & Guha[5] have reported about the formation of sharp boundaries on electrolysis in a U-tube and W-tube under non-glow conditions. Londiche and Lancelot[6, 7] have also reported their work in boundary formation of U-tube.

In the present paper we have reported the work done by carrying out desalination of Lonar lake water samples, collected from different parts of the lake, at 400 V dc, in an optimized W-cell[8] having internal diameter 15 mm and central height 20 cm, giving optimum yield of potable water with minimum consumption of electrical energy. We have also investigated the phenomenon of "cessation of ionic migration" in this work.

EXPERIMENTAL

The experimental arrangement used for carrying out desalination of Lonar lake

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water samples is depicted in Fig. 1. Optimized W-cell,[8] with internal diameter 15 mm and central uphill height of 20 cm was fabricated from corning glass tubings. A jacket was provided to the cell, for carrying away the heat generated during electrolysis of Lonar lake water samples, with the help of water flowing through the jacket. The W-cell was filled with given samples of Lonar lake. Then a constant dc voltage of 400 V was applied from a specially prepared power supply which could give dc voltage in the range of 0 to 800 V and current up to 1 amp, to the platinum electrodes, dipped in the two limbs of W-cell. After application of the constant dc voltage to the electrodes, the current flowing through the electrolyte, at given time intervals, was noted down. It was found that the current initially increased, reached a maximum and started decreasing, finally becoming nearly zero (Table-1 and 2). After cessation of current, three distinct zones appeared to be formed in the three limbs of W-cell. After the cessation of the current, samples of solutions, from the three regions (namely cathode, anode and the central region) were taken out for pH measurements (using Equiptronics Portable pH meter Model EQ-612). The pH measurements of the three zones indicated that the solution in the cathodic region was distinctly alkaline, that in the central zone was neutral and the solution in the anodic region was distinctly acidic (Table 5). To determine the potability of water collected from central region, the Most Probable Number (MPN) test carried out confirmed the water to be potable. The MPN report is as follows: *If MPN of given samples is zero. It indicates that the given water sample is not contaminated by fecal matter. Hence there is absence of any pathogenic M.O.S. Therefore the sample is potable.*

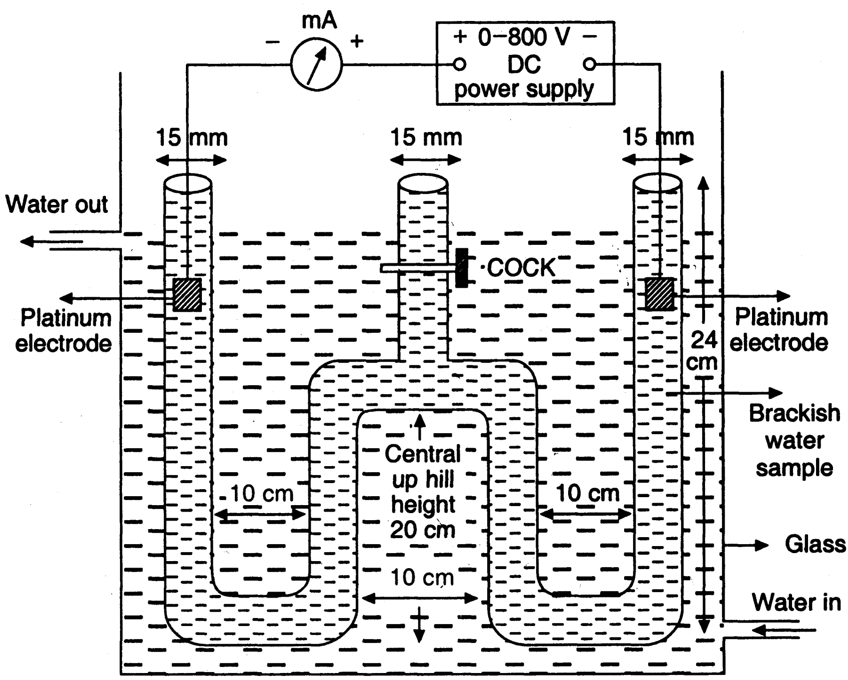

Fig. 1 Experimental arrangement for optimization of W-cells

TABLE-1
ELECTROLYSIS OF LONAR LAKE WATER SAMPLES USING OPTIMIZED W-CELL

Internal diameter of W-cell = 15 mm
Central uphill height of W-cell = 20 cm
Electrodes used = Platinum
Applied dc voltage = 400 V
pH of Lonar lake sample before electrolysis = 8.93

Sr. No.	Time min	Current mA	Sr. No.	Time min	Current mA
1	00	04	11	550	12
2	10	05	12	580	13
3	60	05	13	605	14
4	130	05	14	640	13
5	190	06	15	665	12
6	310	07	16	700	10
7	355	08	17	730	08
8	400	09	18	780	06
9	465	10	19	830	04
10	520	11	20	860	02

TABLE-2
ELECTROLYSIS OF LONAR LAKE WATER SAMPLES USING OPTIMIZED W-CELL

Internal diameter of W-cell = 15 mm
Central uphill height of W-cell = 20 cm
Electrodes used = Platinum
Applied dc voltage = 400 V
pH of Lonar lake sample before electrolysis = 10.1

Sr. No.	Time min	Current mA	Sr. No.	Time min	Current mA
1	0	55	17	525	181
2	15	60	18	555	170
3	30	62	19	590	159
4	35	65	20	640	142
5	70	70	21	690	134
6	140	87	22	750	126
7	195	97	23	810	111
8	240	107	24	870	102
9	270	112	25	930	82
10	300	115	26	990	74
11	315	120	27	1050	63
12	330	128	28	1100	41
13	360	134	29	1160	33
14	385	140	30	1220	18
15	420	152	31	1280	09
16	480	173	32	1310	05

RESULTS AND DISCUSSION

After carrying out electrolysis in W-cell as discussed earlier, the total electrical power consumed in the electrolysis of the samples was calculated from a graph plotted between dc current and time (Fig. 2 and 3) and using the formula

$$\text{Total electrical power (in kWH)} = \frac{\text{Time interval} \times \text{Voltage} \times \text{Current}}{60 \times 10^6}$$

The calculations and results are shown in Table-3 and Table-4 respectively.

TABLE-3
VALUES OF POWER CONSUMED IN W-CELL
(refer Table-2)

Internal diameter of W-cell = 15 mm
Central uphill height of W-cell = 20 cm
Applied dc voltage = 400 V
pH of Lonar lake sample (before electrolysis) = 10.1
Time interval = 60 min

Sr. No.	Current range mA	Average current mA	Power = $\frac{V \times i \times t}{60 \times 10^6}$ kWH
1	55–68	61.5	0.0246
2	68–80	74	0.0296
3	80–93	86.5	0.0346
4	93–105	99	0.0396
5	105–120	112.5	0.0450
6	120–135	127.5	0.0510
7	135–155	145	0.0580
8	155–173	164	0.0656
9	173–181	177	0.0708
10	181–160	170.5	0.0682
11	160–140	150	0.0600
12	140–127	133.5	0.0534
13	127–114	120.5	0.0482
14	114–100	107	0.0428
15	100–88	94	0.0376
16	88–76	82	0.0328
17	76–63	69.5	0.0278
18	63–50	65.5	0.0226
19	50–36	43	0.0172
20	36–25	30.5	0.0122
21	25–13	19	0.0076
22	13–5	9	0.0036
23	5–0	2.5	0.0010
		Total power consumed =	0.8538 kWH

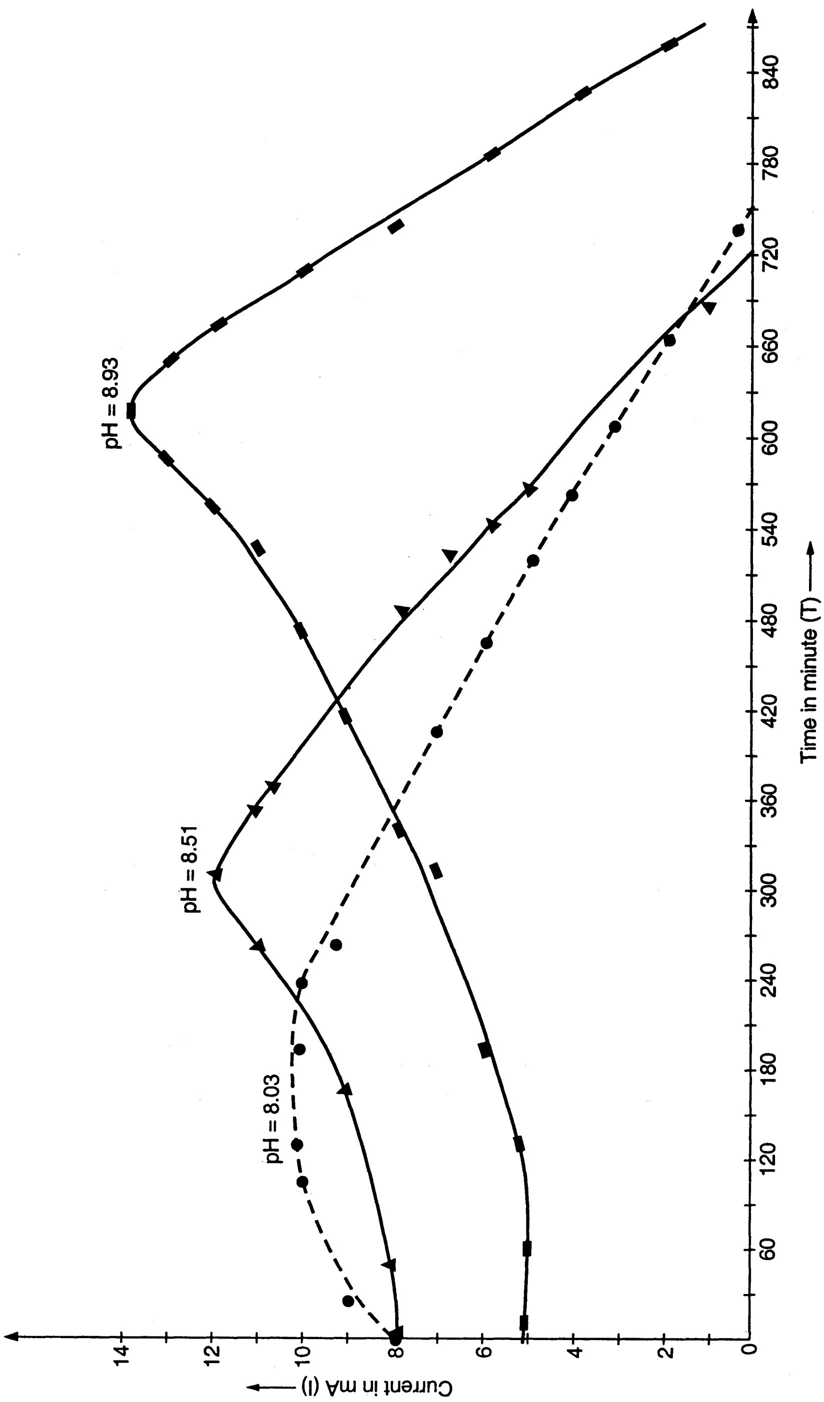

Fig. 2 Plot of dc current versus time for W-cells

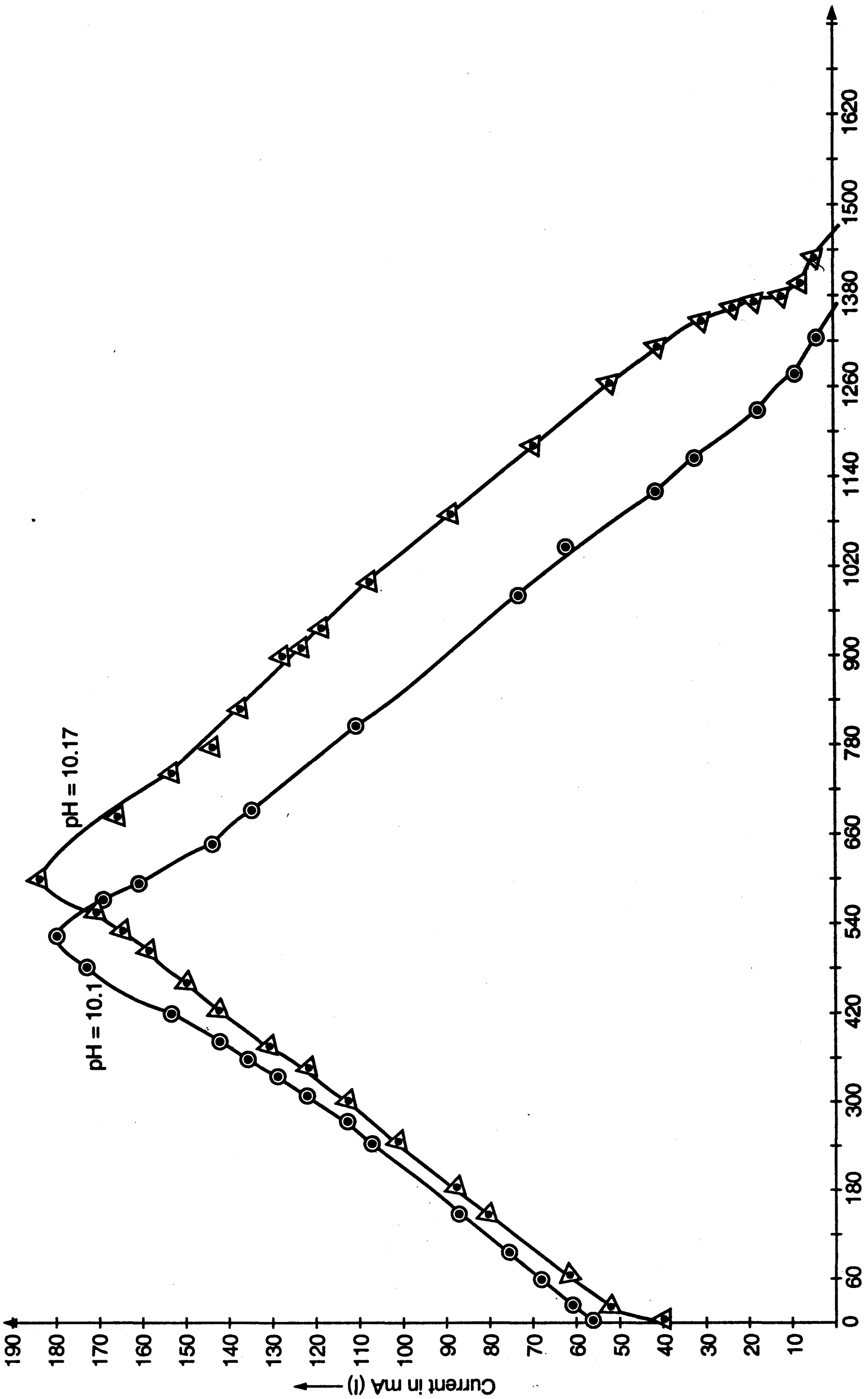

Fig. 3 Plot of dc current versus time for W-cells

TABLE-4
TOTAL ELECTRICAL POWER CONSUMED IN ELECTROLYSIS OF DIFFERENT SAMPLES OF LONAR LAKE IN OPTIMIZED W-CELL

Internal diameter of W-cell = 15 mm
Central uphill height of W-cell = 20 cm
Applied dc voltage = 400 V

Sr. No.	pH of samples before electrolysis	Value of saturation current mA	Total power consumed after formation of complete isolated zones kWH
1	8.03	10	0.03294
2	8.51	12	0.03688
3	8.93	14	0.04557
4	10.10	18	0.85380
5	10.17	185	1.07960

These studies have yielded unexpectedly very startling and interesting results. One of the most important results and findings is that, after a prolonged electrolysis in W-cell and after cessation of electric current, potable water is always formed in the central region of W-cell, even though the applied voltage remains constant.

In the electrolysis process in W-cell, initial diffusion controlled ionic migration takes place, after application of dc voltage to the two electrodes, thereby increasing the current gradually (Fig. 2). However, due to high applied dc voltage, the fast moving ions, in opposite directions, find it difficult to deliver their charges to the respective electrodes. This situation prohibits the current to increase further and, thereby, the current saturates. The ionic motion is twice under gravity and twice against it due to the special geometry of W-cell. This reduces the ionic mobility of H^+ and OH^- ions and these ions get retarded. Under this type of motion and suitable conditions, it is quite probable that the $H^+$and OH^- ions can give exothermic recombination, thereby producing water in the central zone.

The heat generated in the electrolysis process is much more than the expected I^2R joule heating because it is a non-faradic process carried out at a much higher dc voltage. Because of this the electrolyte becomes very hot and normal ionic migration is hindered. It, therefore, appears that some unusual exothermic reactions do take place under such non-faradic electrolysis. This probably is the possible reason for larger heat generated in the above process.

Sengupta and Palit[9], in their paper "Theory of double boundary formation on electrolysis in W-tubes" have proposed electrodically generated additional ions, H_3O^+ and OH^-. These ions eventually drive out electrolyte ions due to "Sweeping out" mechanism from central region. The depletion of ions from the central zone makes it more and more non-conducting. In other words, its potential gradient increases due to loss of free ions, resulting in an increase in the resistance of central region of W-cell. At the same time, there is an accumulation of ions in the cathode and anode regions whose conductivity goes on increasing. Finally when the conductivity is maximum, potential gradients in the anode and cathode regions become zero. This non-uniform electrical resistance, developed in the three regions, explains the "cessation of current" at the end of eletrolysis.

TABLE-5
pH VALUES OF LONAR LAKE WATER SAMPLES, BEFORE AND AFTER ELECTROLYSIS, IN OPTIMIZED W-CELL

Internal diameter of W-cell = 15 mm
Central uphill height of W-cell = 20 cm
Applied dc voltage = 400 V

Sr. No.	pH of Lonar lake water sample before electrolysis	pH of Lonar lake water samples after electrolysis (samples collected from three zones)
1	8.03	pH of acid = 2.01
		pH of alkali = 12.20
		pH of potable water = 7.42
2	8.93	pH of acid = 2.15
		pH of alkali = 12.20
		pH of potable water = 7.55
3	10.17	pH of acid = 2.15
		pH of alkali = 11.90
		pH of potable water = 7.28
4	8.51	pH of acid = 1.93
		pH of alkali = 12.28
		pH of potable water = 7.35
5	10.10	pH of acid = 1.21
		pH of alkali = 12.8
		pH of potable water = 7.45

Conclusion

Thus this novel process opens up vast possibilities for obtaining (i) Desalination of sea water in a simple and clean way, (ii) Recovery of costly and commercially important by-products such as magnesium hydroxide, bromine, soda lime and sulphuric acid. If the heat generated during the process could be used for power generation, then this method could be economical and self-sustaining.

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