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Reuses Of Wash Water Effluents Of The Ion-Exchanger Units Of Water Demineralization Plant For Economic And Environmental Benefits

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Abstract

In industrial field, a large volume of regenerants (acid and caustic soda) and their washing effluents are regularly disposed off from the water demineralization plant during regeneration of the ion-exchanger units. Of these waste effluents, a part of the wash water discharged from the single bed Anion and Mixed Bed units can be utilized at a certain stage of their washing cycles when its conductivity is fallen down and becomes considerably less than that of the input raw water. The main aim of this specific waste effluent utilization is to dilute the TDS concentration of the input raw water (fed into the single bed ion-exchanger units) by blending. The achievement is the increase of the longevity of the production cycles of the I.E. units along with the improvement of the production quality and decrease of the regeneration frequencies. As a result, regenerant consumption would be saved because of the reduction of ionic load in feed water which will ultimately reduce the water purification cost. At the same time, the environment pollution will also be protected to a considerable extent. This operational measure is quite effective and useful specially where high TDS water is demineralized only by single bed ion-exchangers. In such case, the water treatment plant is very often found to suffer from both production quality and quantity in addition to carrying out of random and restless regenerations. Proper reuses of the aforesaid wash water effluents of the Anion and MB units excellently minimizes the difficulties experienced in practice. This paper contains the utilities and techniques of reuses of the different kinds of waste effluents of the industrial water treatment plant in addition to the specific reuses of the post-regeneration wash waters of the Anion and MB ion-exchanger units.

Introduction

A large volume of different kinds of effluents are regularly disposed off from industrial water treatment plants during operational processing of the clarifier, sand filters and ion-exchanger units. The most common waste effluents of a conventional deionization plant are mainly-

1. Sludge of the clarifier.
2. Backwash water of the sand filters.

3. Backwash water of the cation, anion and mixed bed exchangers.
4. Acid regenerant (HCl/H_2SO_4) of the single bed cation and mixed bed exchangers.
5. Caustic regenerant (NaOH) of the single bed anion and mixed bed exchangers.
6. Rinse water of all ion–exchanger units.
7. Final wash water of all ion–exchanger units.

Generally, the plant designers and manufacturers do not consider rather ignore the benefits of the reuses of the waste effluents while designing water treatment plants. Whereas reusing of some of the above waste effluents can play significant role not only in minimizing the environmental pollution but also in economizing the operation cost of a treatment plant simultaneously with some technical benefits . The increase of the production efficiencies of the ion–exchanger units both by quality and quantity is one of them main considerations.

Considering this fact, some plant engineers and chemists are recently found to practise with the reuses of the waste regenerants (both acid and caustic soda) by applying the so–called Throughfare Regeneration [1,2] technique having done some minor modifications and additions in the plant at the site. According to them, 15–20% regenerants can be saved [3] by utilizing the waste regenerant effluents although there are some controversial opinions of many plant designers and site chemists about the savings in practice [3]. They opin that the saving is practically quite small in quantity which have a little value. Rather the application of the throughfare regeneration causes some technical difficulties in operation of the deionizer units [3].

However, the benefits of the reusing of the post-regeneration wash water effluents of the anion and mixed bed exchangers are still overlooked almost in everywhere. Its reuses and benefits are the main object of the paper. In consideration of this fact, the technical benefits of reusing the post-regeneration wash water effluents regularly disposed off from the anion and mixed bed units have been studied by this research [4].

This specific study has been done directly on two different commercially operated deionization plants. One of the plants consisted of SAC-D-SBA-MB ion-exchanger units and the other one was only SAC-SBA. The experimental results of the qualitative and quantitative achievements are shown in Table-2. The multi-purpose utilizations of the other different waste effluents of a deionization plant are shown in Fig. 2 with their brief discussion in Table-3.

Experimental

Principle : Reduction of TDS concentration in input raw water of the single bed deionizer units by blending with low TDS (or TDS free) water.

Relevant Information of the Experiments :

Table-1. Analytical results of the raw water and wash water effluents used for the experiment purpose.

Parameters and Units	Tubewell Water (TW)	River Water (RW)		Waste Water Effluent (WWE)	
		1	2	1	2
Conductivity, μS/cm	1072	560	460	32	1.0
TDS, meq/l	13.3	6.15	4.9	0.07	0.4
Calcium, meq/l	2.4	2.5	2.4	00	00
Magnesium, meq/l	1.6	1.0	1.0	00	00
Sodium, meq/l	9.3	2.65	1.5	0.07	00
p–Alk. meq/l	00	00	00	0.07	00
m–alk, meq/l	8.7	3.5	3.5	–	00
Chloride, meq/l	4.5	2.15	1.0	–	–
Sulphate, meq/l	0.1	0.5	0.4	–	–

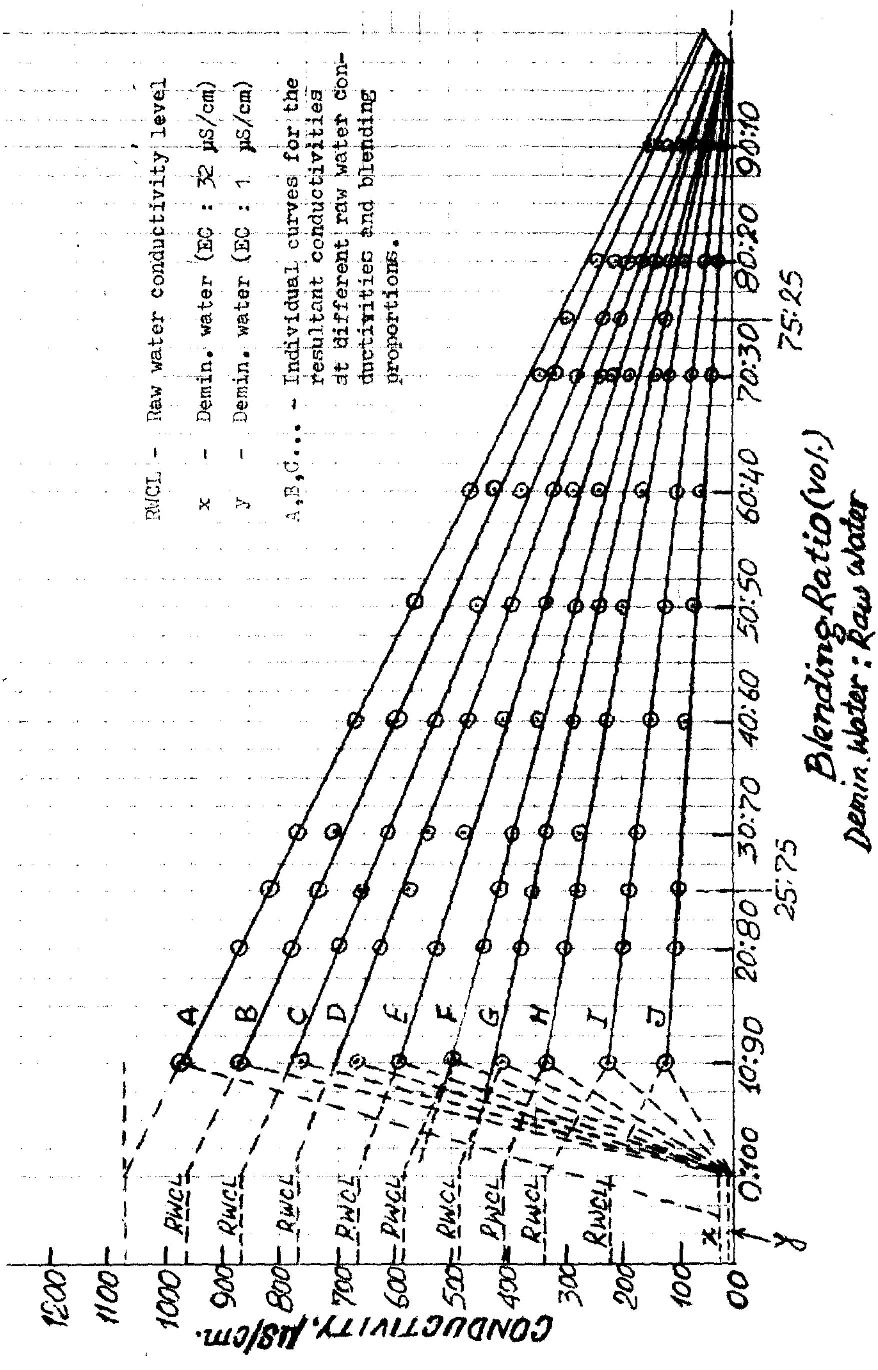

Fig.2 . Phenomenon of the rate of decrease of raw water conductivity of different magnitudes when blended with demineralised water.

Procedure :

(a) ***Laboratory Experiment.***

Before applying the plant scale experiment, the resultant conductivities at different mixing proportions of high and low conductivity water as specified in Fig.1 were pre-determined by laboratory tests. This was done in view of making a generalized guideline for assuming the approximate mixing proportion of the two components of the blend water for desired TDS level.

(b) ***Plant Scale Experiment.***

After completion of the regeneration process followed by primary rinsing, when the conductivity of the final wash water effluent discharging from the regenerated anion or mixed bed unit decreased to less than that of the initial input raw water (i.e. clarified water), then it was first blended to the influent water of the clarifier. Thereafter, when the conductivity of the wash water was decreased more and became less than 20 μS/cm, the stream of blending was then diverted from clarifier to the cation unit inlet. The experimental results are furnished in Table.2.

Results and Discussion

The achievement of the application of the said methodology for the reuses of the waste wash water effluents of the anion and mixed bed exchangers done by the plant scale experiment found quite remarkable and excellent. The beneficial effects may be noted from the comparative results of the improvement of the production quality, quantity, running cycle longevity and other correlated operational parameter of the single bed cation and anion units before and after application of the methodology as depicted in Table.2. The increase of the production cycle longevity decreased the regeneration frequencies and hence savings of the regenerants which leaded economic operation of the plant. Lesser the wash water conductivity, more the achievements.

Because of high sodium content in the experimental input raw water, Na-leakage from the cation units was quite high before blending process. This affected badly the production quality of the single bed anion units caused high conductivity, silica and p-alkalinity. But after blending the low conductivity wash water effluent, the Na-leakage was minimized to a minimum level or zero. As a result, the p-alk, conductivity and silica were improved to a satisfactory level.

The analytical results of the Table-1 indicated the quality of the input raw water and wash water effluents of the anion and mixed bed exchangers used for the experiment. All the plotted curves of the 'resultant conductivities' in Fig.1 are applicable in general within the specified maximum limits of input raw water conductivities. Therefore, one can easily pre-determine the resultant conductivity and mixing proportion from any suitable curve appropriate for the raw water and desired resultant conductivity of the bled water.

At the rinsing stage of the regenerated anion and mixed bed exchangers, the conductivity of their rinsed water effluents is normally too high due to high concentration of the residual caustic regenerant. Hence the primary rinsed effluent should not be used for the purpose. But this high concentrated caustic effluent may be collected separately and can be reused for coagulation purpose provided if it is done in alkaline medium. Thereafter, when the conductivity of the washing effluent decreases and becomes 40-50 μS/cm lesser than that of the input raw water, then it may be first blended directly to the influent water of the clarifier in order to utilize the residual caustic soda for the coagulation process. When the

Table- 2

Experimental results of the reduction of TDS of the input raw water after blending wash water effluent of anion and mixed units and its beneficial effects to production quality and quantity of the single bed cation and anion units.

Type of the plant	Conductivity of the input raw water, µS/cm (x)	Conductivity of the wash water blended µS/cm (y)	Blending proportion, x : y	Resultant conductivity of the blend water (at inlet of cation unit), µS/cm	Duration of one production cycle/regeneration, hr.				Production quantity per regeneration per unit, m^3				Production quality					
					Cation unit		Anion unit		Cation unit		Anion unit		Cation unit		Anion unit			
					Before blending	After blending	Before blending	After blending	Before blending	After blending	Before blending	After blending	Na-leakage meq/l		Before blending		After blending	
													Before blending	After blending	p-Alk. meq/l	EC µS/cm	p-Alk. meq/l	EC µS/cm
A	1072	32	70:30	760	16	28	30	46	800	1400	1500	2300	.07	.001	.07	32	.001	7
	1072	32	60:40	660	16	38	30	51	800	1900	1500	2550	.07	*T	.07	32	T	5
	560	1	70:30	392	40	56	44	58	2000	2800	2200	2900	.002	00	.002	6	00	4
B	460	1	50:50	238	8	26	4	15	120	400	60	225	.05	00	.05	18	00	2.8

*(T - Trace)

conductivity decreases more and becomes <20 μS/cm, the blending stream should be diverted from the clarifier inlet to the filtered water reservoir. But for proper and uniform mixing, it is better to add this wash water either to sand filter outlet or cation unit inlet at any suitable point as shown as Fig.2.

The wash water effluents of the anion units contain high residual p-alkalinity,. Hence this will cause an increase of the alkalinity of the resultant blend water (i.e. the mixture of the raw water and wash water) where coagulation is done in alkaline medium In such case, the output conductivity of the caiton unit sometimes may be decreased and smaller than or equal to that of its input water. This will depend upon the added amount of residual p-alkalinity. This is happened due to neutralization of the OH^- ions by the equivalent amount of the FMA (free mineral acid) liberated in the cation exchanger unit according to the following ion-exchange reactions.

Reactions: :

$$R\text{-}H^+ + M^+A^- + NaOH \rightarrow R\text{-}M^+ + H^+A^- + OH^- \quad \text{.................} (1)$$

$$H^+A^- + OH^- \rightarrow H^+A^- + H_20 \quad \text{.................} (2)$$

where, M^+A^- – strong mineral salts [e.g. NaCl]
$R\text{-}H^+$ – H^+-form cation resin
H^+A^- – FMA

In the case of alum treated clarified water, such behavior of the conductivity of the cation unit output may not be observed because of its acidic nature. Here the added OH- ions in the wash water will be neutralized by the acidic clarified water before pass it through the cation units. It may be pointed out that in case of alum treated coagulation, the addition of alkaline wash water may disturb to occur proper coagulation because of the increase of its optimum pH (normally maintained 5.5–6.0 But in alkaline medium coagulation, the high p–alkalinity of the wash water effluent specially discharged from the anion unit would help to occur good coagulation with simultaneous saving some quantity of caustic soda (if used for coagulation). This is an additional economic benefit.

At the final stage of washing, a considerable volume of highly pure water (conductivity less than 10 μS/cm from the anion unit and less than 5 μS/cm from MB unit) remarkably reduces the TDS level of the input raw water (see Fig. 1).

The application of the anion/MB wash water blending methodologyis very effective specially where high TDS raw water is to use for small capacity deionization plant having no mixed bed polishers. Because in such plants, the running hours of the production cycles of the single bed ion exchanger units are usually quite short. In some of such plants, the ion–exchanger units are found to be exhausted so frequently that before completion of the regeneration of the exhausted unit, the running unit of the other train fallen into exhaustion. As a result, shortfall of treated water is very often experienced which interrupts the smooth supply of treated water to the end use.

The possible reuses of the other waste effluents of the conventional deionization plant planned by this research are shown in Fig. 2.

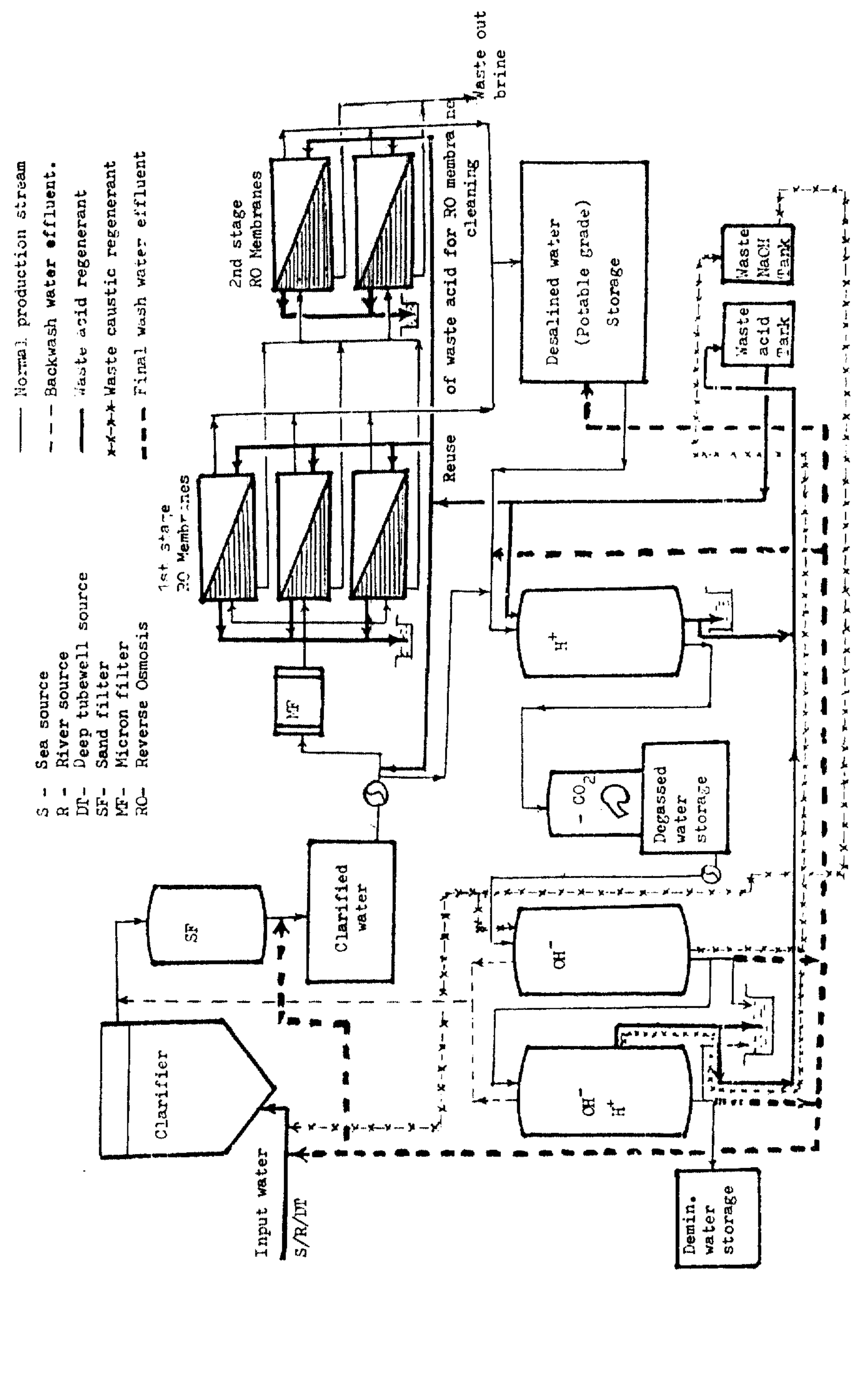

Fig. 2 . A plan of the proper and beneficial reuses of the waste effluents of Deionisation plant.

Table–3. A chart for the reuses of some usable waste effluents of a deionization plant and their purposes.

Waste effluents	Purpose of reuses
1. Sludge of clarifier unit	1. For efficient coagulation of low turbid surface water as a substitute of polyelectrolytes. Its effectiveness found poor.
2. Post-regeneration effluents of the acid regenerant of Cation and MB units.	2. (a) For primary [2] regeneration of the single bed cation exchanger units. (b) Acid conditioning of the RO feed water as an inhibitor to prevent carbonate fouling [5] on the membranes. Effluent of the H_2SO_4 regenerant for this purpose is more advantageous than that of HCl [6]. (c) For acid regenerant dilution. (d) For coagulation process as a coagulant aid [7] of alum for easy maintaining the optimum pH in acidic region (pH 5–5.5) if required.
3. Post-regeneration effluents of caustic regenerant (NaOH) of the anion and MB units.	3. (a) For primary [2] regeneration of the single bed anion units. (b) For coagulation process as an aid of iron coagulant for easy adjustment of pH in alkaline region. (c) For caustic soda dilution. (d) For pH adjustment of the RO permeate prior to supply it for potable use [5].
4. Finial wash water effluents of the anion and MB units.	4. (a) For the reduction of input water TDS of deionization plant. (b) For TDS adjustment of desalinated water of RO plant for drinking purpose. (c) For the purpose of caustic soda dilution. (d) For TDS reduction of the RO feed water.

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