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Studies on the Enhancement of Solute Recovery in Leaching Operation

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Abstract:
Leaching operation is the most generally used operation in industries. In this paper, a system of sand (solid)-Na2CO3 (solute) is taken and from that the recovery of Na2CO3 has been studied by using water as solvent. In this process, we first focused on how the recovery of solute was being affected by the weight of the solute (5, 10, 15, 20, 25 gm) in the mixture and percentage recovery trend was observed and the data was recorded. Then the variation of solute recovery with the weight of solute containing solid (5, 10, 15, 20, 25 gm) was studied and the trend was observed and recorded. Finally we studied about the variations of recovery with the volume of solvent (75, 100, 125, 150, 175 ml) used for the recovery. Then we plotted the characteristic curves for the all the experimental data obtained by the leaching operation.

Keywords: *Enhancement, Leaching, Recovery, Solute, Solvent.*

1. Introduction:

Lixiviation popularly known as leaching exists from ancient times and it has been popular in hydrometallurgy in the extraction of valuable or noble metals from its ores [1-3]. It is the most commonly used process in hydrometallurgy. Leaching is nothing but extraction of the solute (required mineral) from an inert insoluble solid carrier using a liquid solvent medium [4-6].

Various parameters effecting the leaching are [7-9]:

- Solvent volume
- Solute concentration
- Amount of Inert insoluble solute carrying solid that is being processed
- Time of processing or operation
- Temperature

2. Materials and methods:

Experimental setup:
The set up consists of conical flasks, filter papers, funnels, specific gravity (SG) bottle, weighing machine and the chemicals used are sodium carbonate (Na2CO3), sand and water as solvent.
The process variables considered are solvent volume, solute weight and solid weight.

- Solute: Sodium carbonate weight (5,10,15,20,25 gm)
- Solid: Sand weight (5,10,15,20,25 gm)
- Solvent: Water volume (75,100,125,150,175 ml)

Experimental procedure [10-12]:
The procedure starts with the preparation of the solid mixture where sand and Na2CO3 are mixed as per the proportions accordingly. The sand weight was fixed as 5 gm and volume of solvent (water) as 100ml and then 5 solid mixtures consisting of different weights of solute (5, 10, 15, 20, 25 grams)

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was prepared. After preparation, the mixture was transferred into 5 clean and dry flasks and 100 ml of water was added to it. Then stirring was done for sufficient amount of time. Later funnel and filter paper were used to separate the sand from the above obtained solution. The solution obtained is then taken into SG bottle and it's corresponding weight is used to calculate the respective specific gravity and the results were tabulated. This procedure was repeated for 10, 15, 20, 25 gm of sand and the values obtained are tabulated and recorded.

Then the variation of solute recovery with respect to the solvent volume was studied. For that 75 ml of water was taken in 5 flasks and to that 5,10,15,20,25 gm of Na2CO3 was added. Then 10 gm of sand was added to each flask and the mixture was thoroughly stirred. Each sample of clear solution obtained was collected into the SG bottle and specific gravity was calculated and recorded. The same procedure was repeated for 75 ml of solvent taken in 5 flasks each, but with 15, 20 gm of sand. Then the procedure was repeated for 100,150,175 ml of solvent volumes and the observations were noted down.

3. Observations and Results:

Table1: Variation of the recovery with varying solute carrying solid (sand) weight (5,10,15,20,25 gm).

Wt. of sand taken (gm)	Wt. of Na2CO3 taken (gm), W0	Distilled water added (ml)	Volume of separated clear solution(ml)	S.G. of clear solution	Wt.% of NaCl in clear solution (from calibration chart), X	Total weight of clear solution (using S.G. bottle), Y	Wt. of NaCl (gm), W = X*Y	% recovery = 100* W/ W0
5	5	100	98	1.0604	0.0476	74	3.5224	70.448
	10	100	98	1.1104	0.0909	76.4	6.9447	69.447
	15	100	98	1.1479	0.1304	78.2	10.197	67.98
	20	100	99	1.1875	0.1666	80.1	13.344	66.72
	25	100	99	1.2187	0.2	81.6	16.32	65.28
10	5	100	95	1.05	0.0476	73.5	3.4986	69.972
	10	100	95	1.1104	0.0909	76.4	6.9447	69.447
	15	100	96	1.1395	0.1304	77.8	10.145	67.633
	20	100	97	1.1833	0.1666	79.9	13.311	66.555
	25	100	98	1.2229	0.2	81.8	16.36	65.44
15	5	100	96	1.0442	0.0476	93.3	4.4410	88.82
	10	100	96	1.0845	0.0909	95.3	8.6662	86.62
	15	100	97	1.1287	0.1304	97.5	12.714	84.76
	20	100	97	1.1690	0.1666	99.5	16.576	82.88
	25	100	98	1.2012	0.2	101.1	20.228	80.88
	5	100	95	1.0479	0.0476	93.844	4.467	89.346

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20	10	100	95	1.0937	0.0909	96.083	8.734	87.34
	15	100	95	1.1333	0.1304	98.059	12.787	85.253
	20	100	96	1.1687	0.1666	100.50	16.744	83.72
	25	100	97	1.2062	0.2	101.93	20.386	81.544
25	5	100	88	1.0394	0.0476	95.757	4.5575	91.15
	10	100	93	1.0889	0.0909	97.840	8.8937	88.937
	15	100	93	1.1323	0.1304	99.470	12.971	86.475
	20	100	94	1.1674	0.1666	101.52	16.914	84.573
	25	100	95	1.2149	0.2	103.11	20.622	82.49

Table2: Variation of recovery with solvent volumes (75,100,150,175ml) in system consisting of 10 grams of sand.

Wt of Na2CO3 taken (gm), W0	Distilled water added (ml)	Volume of separated clear solution(ml)	S.G. of clear solution	Wt % of NaCl in clear solution (from calibration chart), X	Total weight of clear solution (using S.G. bottle), Y	Wt of NaCl (gm), W = X*Y	% recovery = 100* W/ W0
5	75	71	1.0244	0.0625	58.0	3.6250	72.5
10		71	1.1004	0.1176	59.3	6.9736	69.73
15		71	1.1295	0.1666	60.4	10.062	67.08
20		71	1.1375	0.2105	61.2	12.882	64.41
25		73	1.2015	0.25	62.8	15.7	62.8
5	100	95	1.05	0.0476	73.5	3.4986	69.972
10		95	1.1104	0.0909	76.4	6.9497	69.447
15		96	1.1395	0.1304	77.8	10.145	67.633
20		97	1.1833	0.1666	79.9	13.311	66.555
25		98	1.2229	0.2	81.8	16.36	65.44
5	150	148	1.0281	0.0322	92.5	2.9785	59.570
10		148	1.0583	0.0625	94.0	5.8750	58.75
15		146	1.0865	0.0909	95.4	8.6718	57.812
20		146	1.1086	0.1176	96.5	11.348	56.742
25		145	1.1408	0.1428	98.1	14.008	56.034
5	175	170	1.0261	0.0277	92.4	2.5594	51.189
10		171	1.0482	0.0541	93.5	5.0583	50.583
15		172	1.0744	0.0789	94.8	7.4797	49.864

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20		173	1.1006	0.1025	96.1	9.8502	49.251
25		173	1.1267	0.125	97.4	12.175	48.70

Table 3: Variation of recovery with solvent volumes (75,100,150,175ml) in system consisting of 15 gm of sand.

Wt of Na_2CO_3 taken (gm), W0	Distilled water added (ml)	Volume of separated clear solution(ml)	S.G. of clear solution	Wt % of NaCl in clear solution (from calibration chart), X	Total weight of clear solution (using S.G. bottle), Y	Wt of NaCl (gm), W = X*Y	% recovery = 100* W/ W0
5	75	69	1.0244	0.0625	57.9	3.6187	72.375
10		69	1.1004	0.1176	59.1	6.9501	69.501
15		70	1.1295	0.1666	60.2	10.032	66.88
20		71	1.1375	0.2105	61.3	12.903	64.515
25		71	1.2015	0.25	62.8	15.7	62.8
5	100	96	1.0442	0.0476	93.3	4.4410	88.82
10		96	1.0845	0.0909	95.3	8.6627	86.627
15		97	1.1287	0.1304	97.5	12.714	84.76
20		97	1.1690	0.1666	99.5	16.582	82.91
25		98	1.2012	0.2	101.1	20.22	80.88
5	150	147	1.0382	0.0322	93.0	2.9946	59.892
10		144	1.0623	0.0625	94.2	5.8875	58.875
15		142	1.0885	0.0909	95.5	8.6809	57.873
20		141	1.1126	0.1176	96.7	11.371	56.859
25		140	1.1509	0.1428	98.6	14.080	56.32
5	175	171	1.0221	0.0277	92.2	2.5539	51.078
10		172	1.0462	0.0541	93.4	5.0529	50.529
15		173	1.0764	0.0789	94.9	7.4876	49.917
20		173	1.1026	0.1025	96.2	9.8605	49.302
25		173	1.1327	0.125	97.7	12.212	48.850

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Table 4: Variation of recovery with solvent volumes (75,100,150,175ml) in system consisting of 20 gm of sand.

Wt of Na2CO3 taken (gm), W0	Distilled water added (ml)	Volume of separated clear solution(ml)	S.G. of clear solution	Wt % of NaCl in clear solution (from calibration chart), X	Total weight of clear solution (using S.G. bottle), Y	Wt of NaCl (gm), W = X*Y	% recovery = 100* W/ W0
5	75	66	1.0244	0.0625	57.8	3.6125	72.250
10		67	1.1004	0.1176	59.4	6.9854	69.854
15		68	1.1295	0.1666	60.3	10.045	66.973
20		70	1.1375	0.2105	61.5	12.945	64.728
25		71	1.2015	0.25	62.4	15.6	62.40
5	100	95	1.0479	0.0476	73.4	3.4931	69.868
10		95	1.0937	0.0909	76.4	6.9447	69.477
15		95	1.1333	0.1304	77.8	10.145	67.633
20		96	1.1687	0.1666	79.9	13.311	66.555
25		97	1.2062	0.2	81.0	16.36	65.44
5	150	135	1.0342	0.0322	92.8	2.9881	59.763
10		144	1.0482	0.0625	93.5	5.8437	58.437
15		139	1.0925	0.0909	95.7	8.6991	57.994
20		140	1.1187	0.1176	97.0	11.407	57.036
25		140	1.1509	0.1428	98.6	14.080	56.320
5	175	168	1.0321	0.0277	92.7	2.5679	51.355
10		168	1.0523	0.0541	93.7	5.0691	50.691
15		168	1.0744	0.0789	94.8	7.4797	49.864
20		170	1.1046	0.1025	96.3	9.8707	49.353
25		170	1.1307	0.125	97.6	12.2	48.80

Table 5: Calibration chart for the system

S no.	Weight of water,(gm)	Na2CO3 weight , (gm)	Weight % of Na2CO3 concentration	S.G of the sample
1.	100	5	0.04761	1.05625
2.	100	10	0.0909	1.10625
3.	100	15	0.13043	1.15
4.	100	20	0.16667	1.16666
5.	100	25	0.2	1.22083

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4. Results and Discussions:

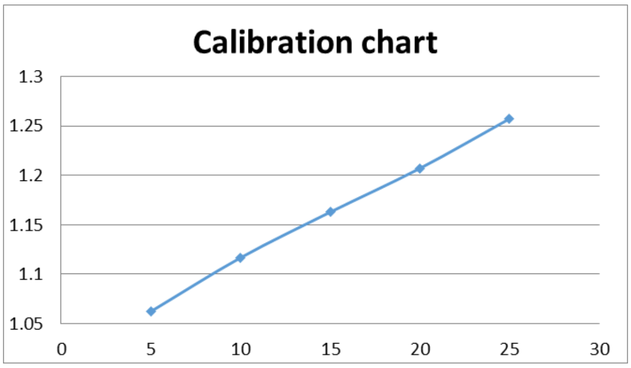

Figure 1: Calibration chart for the system of sand-Na2CO3 and water for SG vs. weight of solute

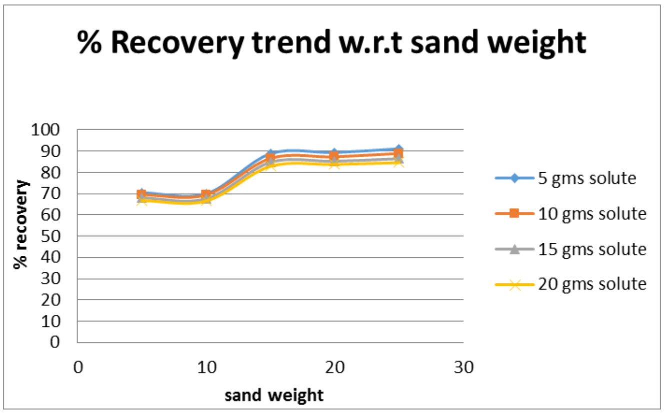

Figure 2: Variation of % recovery with sand weight in system of 100ml of solvent volume.

In Figure 2, the solute recovery trend with sand weight has been studied. It is observed that at lower weights of sand such as 5, 10 gm of sand the trend is almost similar and is decreasing but the recovery is higher for higher values of sand weight.

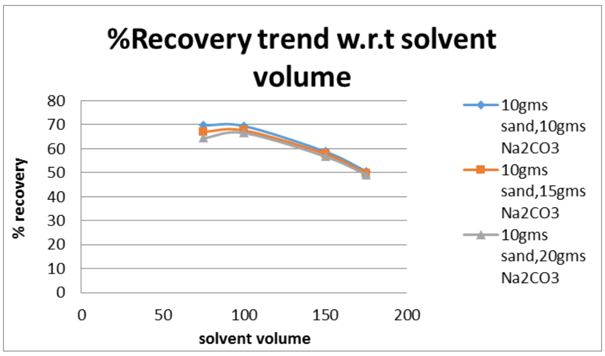

Figure 3: Variation of % recovery with respect to solvent volume with 10 gm of sand

In Figure 3, the solute recovery trend with solvent volume for 10 gm of sand has been studied. It is observed that the recovery is decreasing with the increase in solvent volume.

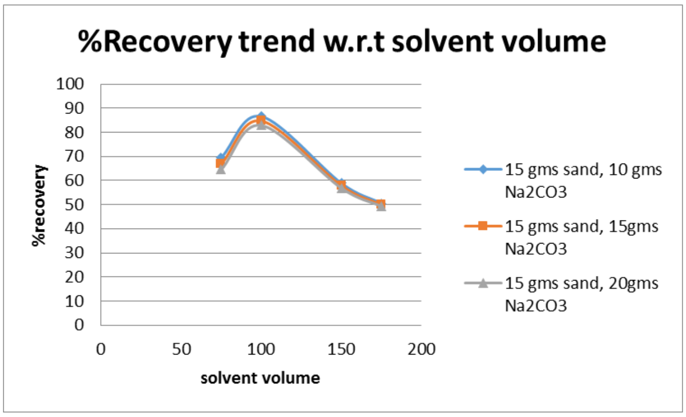

Figure 4: Variation of % recovery with respect to volume of solvent with 15 gm of sand.

In Figure 4, the solute recovery trend with solvent volume for 15 gm of sand has been studied. A clear rise in the recovery is observed and again after increase in solvent volume more than 100, there is a gradual fall in the recovery trend.

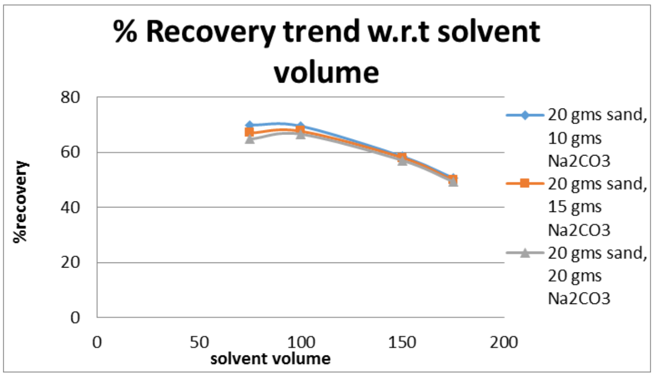

Figure 5: Variation of % recovery with respect to solvent volume with 20 gm of sand

In Figure 5, the solute recovery trend with solvent volume for 20 gm of sand has been studied. The trends are almost similar to that of the case of 10 gm sand system.

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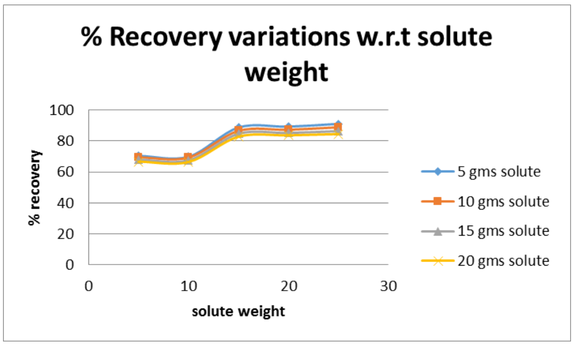

Figure 6: Variation of % recovery with solute weight

In Figure 6, the % recovery with solute weight is studied. There is a sharp rise in the %recovery after a weight of 10 gm and when higher amounts of solute were taken the recovery was almost similar. So we can say that the optimum weight of solute is 15 gm.

5. Conclusions:

From experimentation, the variations of % recovery of solute with respect to different process variables were studied. The recovery was more for higher amount of sand, because it provides enough void spaces for solvent to come in contact with the solute particles, thereby allowing more solute to get dissolved into the solvent, resulting in increased solute recovery. But for higher amounts of solvent, the recovery increased to an optimum point and then it decreased thereafter.

Through the experimentation it is observed that there is a sharp increment in the % recovery with the increase in solute weight for an optimum weight of sand and at higher amounts of solute the recovery is almost the same.

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