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SEWAGE FAT RECOVERY AND CHARACTERIZATION

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Experiments were conducted for the extraction of fatty matter from dried primary sludge and protein free primary sludge, using naphta as solvent which is available locally as refinery surplus and is comparatively cheaper. On the average, the percentage recovery of fats from primary sludge and protein free primary sludge were almost identical and thus it was established that the protein separation does not effect the recovery of fat. With a view to characterize the extracted fat, in either case, parameters such as iodine value, saponification value, I.N.S. factor, F.F.A. (%) and acid value were determined. Further the comparison of the experimental values of the parameters with those of standard fatty material reveal that there are fair indications that the extracted fat can be put to profitable use.

Key words: Fat extraction, Fat characterization, Sewage sludge.

Introduction

The use of human refuse dates back to prehistoric times. With the growth in population and parallel increase in scientific knowledge, mechanised mean came into use for treatment of human refuse and domestic municipal wastes which in the course of time also proved a better check on pollution and for the recovery of useful chemical [1]. The available data regarding the recovery of useful components from sewage sludge waste is of preliminary nature and still lacks detailed information required in connection with the development of process and design of units for commercial applications [2-6]. The use of sewage sludge with respect to Pakistan is not very encouraging. The two treatment plants in Karachi, known as TP-1 and TP-II, are treating about 33% of the total waste water generated daily and that too, the sludge produced in these plants is being simply used as a soil conditioner. In order to fill-in the gap and generate necessary data, studies were carried out on the local sewage sludge mainly for recovering fats. This compound was the principle focus of the present investigations.

Materials and Methods

The source of the collection of raw primary sludge was Karachi Metropolitan Corporation treatment plant No. 1 (KMC-TP-I). Prior to collection of samples the pump was allowed to run for 1-2 mins in order to avoid the left over sludge in the pump line and then the sample was collected in containers which were immediately carried to the laboratory for processing. The samples were collected on different days over a period of one year.

Extraction of fats. The primary sludge (P.S.) was screened and divided into two equal portions. The first portion known as primary sludge was thoroughly dried in the sun. 20 Grams of dried samples was ground in a mortar and then 10 ml of conc. HCl (optimized by trial and error maintaining the pH 6.09 to 6.73) was added. The paste thus formed was intimately mixed and again dried in an oven at 80°. The second portion was processed simultaneously, firstly for the separation of protein and subsequently subjected to the recovery of fat. The protein separation was effected by treating 1 liter of screened primary sludge (at pH 6.09-6.73) with 10 gms of sodium hydroxide (molarity 0.25) so as to bring the pH to 12.5. The treated sample was allowed to settle for 24 hrs at room temperature and the supernatent clear layer containing protein was drawn off and the remaining sludge was filtered off. The recovery of the protein has been dealt separately [7]. The sludge thus obtained known as protein free primary sludge (P.F.P.S.) was dried and subsequently treated for fat extraction as described earlier.

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Table 1. Fat Recovery. Comparison of Fat (%) Extracted from Primary Sludge (P.S.) and Protein Free Primary Sludge (P.F.P.S.) Using Naphta as a Solvent.

Sample No.	Fat (%) on dry sludge basis	
	P.S.	P.F.P.S.
1.	20	18
2.	20	19
3.	25	22
4.	22	21
5.	20	22
6.	13	14
7.	20	22
8.	27	24
9.	22	21
10.	17	15
Mean	20.6	19.8
Median	20	21
Mode	20	22
Standard deviation	2.693	3.092
Types of distribution of original samples	Normal	Nearing normal

TABLE 2. CHARACTERIZATION OF FAT FROM PRIMARY SLUDGE (P.S.) AND PROTEIN FREE PRIMARY SLUDGE (P.F.P.S.) USING NAPHTHA AS A SOLVENT.

S ample	Saponification value		Iodine value		I.N.S. factor		F.F.A. (%)		Acid value	
No.	P.S.	P.F.P.S.	P.S.	P.F.P.S.	P.S.	P.F.P.S.	P.S.	P.F.P.S.	P.S.	P.F.P.S.
1.	109	156	21	49	88	107	67	66	132	132
2.	125	153	21	31	104	122	65	67	130	136
3.	154	153	26	29	128	124	70	86	139	136
4.	160	140	30	25	133	115	72	69	144	137
5.	157	149	29	25	128	124	68	69	136	137
6.	182	186	40	44	142	142	71	71	142	141
7.	211	201	22	24	189	177	70	63	140	125
8.	199	189	22	40	177	149	64	71	127	142
9.	203	201	30	29	173	172	73	77	145	154
10.	208	212	35	31	173	181	67	71	132	140
Mean	171	174	27.6	32.7	143.5	141.3	68.7	69.2	136.7	138
Median	171	171	27.5	30	137.5	133	69	69.0	137.5	137
S.D.	33.7	25.02	6.12	8.21	31.88	25.87	2.83	3.54	5.92	7.07

Analysis of fats. The methods employed for the determination of saponification value, iodine value, I.N.S. factor, percentage free fatty acid and acid value were standard one [8-10].

Results and Discussion

Fat recovery. The results of fat extraction from primary sludge and protein free primary sludge using naphtha as a solvent are almost identical with each other (Table 1). The closeness of the values of means and medians in the instaces indicate that the samples tried out were normally distributed. Further the t-test and F-test (Tables 4 and 5) also reveal that fats extracted from primary sludge and protein free primary sludge have no statistically significant difference at all levels of probability. A couple of experiments were carried out by reversing the order of the scheme, i. e., firstly the fat was recovered and then the proteins were separated from the fat free primary sludge. But these reversed studies did not yield encouraging results as the method of protein recovery from fat free primary sludge in addition to being tedious, it consumes a little more alkali and yields less proteins perhaps a portion of protein gets denatured by acid treatment followed by heating. Therefore, it may be safely concluded that to economize the process it would be advantageous to recover proteins first followed by fats.

Characterization of fats. On the average, saponification value, iodine value and I.N.S. factor (Table 2) are slightly higher for the fats extracted from protein free primary sludge. The percentage of free fatty acid and acid value are quite comparable in both fat samples.

Comparison of the characterization factors with those of standard ones of some common fatty matters in Table 3 reveals that the range of the values of these characterization factors for the fat extracted in either case is broad.

TABLE 3. COMPARISON OF DIFFERENT PARAMETERS OF SEWAGE FAT WITH SOME COMMON FATTY MATTERS [8].

Fatty matter	Saponification value	Iodine value	I.N.S. factor
Tallow (Beef)	193-202	35-48	150-151
Tallow (Mutton)	192-197	45-46	157-151
Lard	190-202	53-77	147-125
Commercial grease	185-195	50-55	135-140
Bone grease (Com.)	186-198	48-56	136-142
Sewage Fat (from P.S.)	109-211	21-40	88-189
Sewage fat (from P.F.P.S.)	140-212	24-49	107-181

TABLE 4. t-TEST USING HYPOTHESIS.

Parameters	t-Computed	t-From Table[13] Levels of probability		
		10%	5%	1%
Fat	0.5	1.83	2.26	3.25
Saponification value	0.21	1.83	2.26	3.25
Iodine value	0.32	1.83	2.26	3.25
I.N.S. factor	0.16	1.83	2.26	3.25
F.F.A. % (Oleic)	0.33	1.83	2.26	3.25
Acid value	0.43	1.83	2.26	3.25

TABLE 5. F-TEST ANALYSIS OF VARIANCE.

Parameters	F-Computed	F-From Table[13] Levels of probability	
		5%	1%
Fat	1.43	3.18	5.35
Saponification value	1.83	3.18	5.35
Iodine value	0.56	3.18	5.35
I.N.S. factor	1.50	3.18	5.35
F.F.A. % (Oleic)	0.64	3.18	5.35
Acid value	0.70	3.18	5.35

In practice such a variation seems justified and natural because the values of the characterization factors do depend on the types of discharges which in turn are dictated by a broad spectrum factor. Secondly, it is obvious from the comparison that the values of I.N.S. factors which is criterion of the measure of hardness of soap are greater for the sewage fat which means the soap prepared from fat obtained by these sources would be hard and less detergent. An examination of the values of the means and medians of different characterization factors for sewage fat (extracted either way)reveals that the data in different instances is almost normally distributed [11-12].

Conclusion

In the light of experiments and foregoing discussions it is obvious that fat could be extracted from sewage sludge just using indigenous raw materials. Further there are fair indications that the extracted fat could be put to some profitable use e.g. soap, floor washing solution, metal polishing powder etc. Although there is clear idea concerning various unit operations involved, but the detailed pilot plant studies shall be needed prior to any commercial exploitation of the proposal.

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References

1. W. M. Lewis, *Development in Water Treatment* (Applied Science Publisher Ltd., London, 1980), 2nd ed., Vol. 2, pp. 27.
2. M. W. M. Bewick, *Handbook of Organic Wasate Conversions* (Von Nostrand Reinhold Co., London, 1980), Ist ed., pp. 102.
3. Syed R. Qasim, *Waste Water Treatment Plant, Design and Operation* (C.B.C. Publishing Co., Tokyo, 1986), Ist ed., pp. 73.
4. Mark. J. Hammer, *Waste and Waste Water Technology* (John Wiley & Sons, New York, 1977), pp. 23.
5. Ernest W. Steel, *Water Supply and Sewerage* (McGraw Hill Co., New York 1979), pp. 592.
6. Duane D. Baumann and Daniel M. Dworkin, *Planning for Water Re-use* (Maaroufa Press Inc., Chicago, USA, 1978), pp. 103.
7. M. Altaf Khan, Sajida Chishti and S. Nazar Husnain, Water Res. J., London, UK (accepted for publications).
8. C. Litchfield, *Analysis of Triglycerides* (Academic Press Inc., New York, 1975), pp. 355.
9. Thomas H. Applewhite, *Fats and Fatty Acids, Kirk-Othmer Encyclopedia of Chemical Technology* (John Wiley & Sons., New York, 1985), Vol. 9, pp. 804.
10. W. E. Link, *Official and Tentative Methods of American Oil Chemicals Society* (American Oil Chemical Society, Illinois, USA, 1977), 3rd. ed., pp. 137.
11. L. Galindo, A. Hardisson and F. Garcia, Montalonga Ball, Environ. Contain Toxicol., **36**, 595 (1986).
12. Murray R. Spiegel, *Shaum's Outline of Theory and Practice of Statistics* (McGraw Hill International Book, 1985), pp. 372.
13. Cyril H. Goulden, *Methods of Statistical Analysis* (John Wiley & Sons, New York, 1960), 2nd ed., pp. 108.