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SLUDGE CONCENTRATION WITH A CENTRIFUGAL SEPARATOR

by

R. LOPES CARDOZO, J. VACCAREZZA and S. VANUZZI

1966

Joint Nuclear Research Center
Ispra Establishment - Italy

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- Solids content of concentrated sludge : 11 — 16 w/o.
- Minimalization of radioactive hazards.
- Ease of operation.
- Low costs of treatment.

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CONTENTS

SUMMARY

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- Solids content of concentrated sludge : 11 — 16 w/o.
- Minimalization of radioactive hazards.
- Ease of operation.
- Low costs of treatment.

1. INTRODUCTION

At the Ispra establishment of Euratom, relatively small quantities*) of contaminated water are produced and decontaminated in a classical plant [1] (see Figure I). The method of treatment consists essentially of a calcium-iron-phosphate coprecipitation at pH 11 - 11.5, followed, if necessary, by vermiculite ion-exchange.

Recently, the plant capacity has been increased from 1 - 1.5 to 3.5 m^3/h. This was made possible by addition of an anionic flocculant giving improved floc compactness. In order to prevent some small flocs from being carried over to the vermiculite columns, a sand filter was installed between flocculator and columns. This filter has to be valved in only occasionally.

It appeared that the bottleneck of the installation was the 7 m^3 sludge settling tank, which is definitively too small and produces concentrates of ∽ 1 w/o solids content only.

Therefore, special attention was paid to the volume reduction of the sludges in order to facilitate further treatment, i.e. asphalt insolubilization.

Several ways of sludge concentration (dewatering) are known, see Table I. For comparison, the results of this study are added.

As follows from Table I, drying gives the most compact concentrates. However, dust hazards may make subsequent handling difficult. The other methods yield relatively dry concentrates with considerable effort only.

---

*) 1965 monthly average ∽100 m^3.

TABLE I

Sludge concentration methods.

S = Settling
FT = Freezing - Thawing
F = Filtration
SUD = Sun-drying.

Place	Treatment	w/o Solids in Concentrate	Volume Reduction Factor	Reference
Mol, Belgium	S+FT+F	30 - 40	2000	(2)
Lucas Heights, Australia	S+SUD	50	1800	(3)
Petten, Netherlands	S+FT+F	25		(4)
Los Alamos, U.S.A.	S+F	35 - 40	300 - 800	(5)
Karlsruhe, F.R. Germany	F		140	(6)
Saclay, France	F	30 - 50	60	(7)
Harwell, U.K.	S+FT+F	30	400 - 800	(8)
C.C.R. Euratom	Centrifugal Separator	11 - 16	300 - 800	This report

For small treatment stations, such as is the Ispra plant, it is believed that the sludge treatment should be as simple as possible. The solids content of the concentrate could be between 10 - 20 w/o if the concentrate will be incorporated into asphalt. Here, it plays no important rôle if some more water has to be evaporated provided ample heating is ensured.

In this philosophy, direct mechanical separation without previous sludge settling, fits best. Filtration will give rise to such troubles as clogging of the filter cake unless large amounts of filter aid are used. Separation by centrifugation does not present these difficulties but does not yield concentrates with high solids contents. However, since no special emphasis was put on this factor, direct separation by centrifugation was investigated.

2. SLUDGE CONCENTRATION WITH A CENTRIFUGAL SEPARATOR

2.1. Method

A centrifugal separator*) is normally used for clarification of liquids. The liquid product should be solid-free. On the contrary, in the present case the concentrate should be as dry as possible. The residence time of the sludge in the sludge bowl of the separator should be as long as possible. Discharge should take place, not as usually when the liquid is still solid-free, but around the time when in- and out-flow are of equal concentration. The limit to the dryness of the concentrate is set by its transportability at discharge. Furthermore, it is preferable to remove at each discharge only the most dense part of the concentrate.

After some experimenting, it was possible to trim on-stream times and discharge times in such a way that a compact but still transportable concentrate was obtained.

Just before concentrate discharge, the outflow of the separator is loaded with sludge. Therefore, this liquid was always recirculated to the flocculator.

The flow scheme used is given in Figure II. The sludge from the bottom of the flocculator is continuously

---

*) A description of the separator is given in the Appendix.

removed by a metering pump to the centrifugal separator. The water phase leaves the separator to a 100 l. vessel equipped with two level contacts, placed in such a manner that the recirculation pump, commanded by the contacts, pumps each time a batch of 25 l. back to the flocculator. At regular intervals, the concentrate is discharged into 100 - 200 steel barrels and sent to the asphalt insolubilization.

2.2. Results

The results obtained during 35 days of operation of the separator are given in Table II. To this Table, the following remarks are made:

- Type of operation. Total discharge was investigated during run 1, feeding the separator with $\sim$ 1 w/o solids containing sludge, previously thickened in the sludge settler. During the other runs, the separator was operated with partial discharge and fed with sludge directly from the flocculator.

- Flow to separator, sludge level in flocculator. The magnitude of the flow to the separator is determined by the amount of precipitate formed and by the flow rate of the water treatment. Usually, this value is 2.5 m^3/h with, during runs 6 and 9, values up too 3.5 m^3/h. Once equilibrium is obtained, the sludge level in the flocculator remained constant within some centimeters.

- Concentrate solids contents. These were determined by drying to constant weight at $\sim$ 100°C for $\sim$ 100 hours with intermediate crushing of the partially dried concentrate. Mean values are given from at least two determinations. Comparison of the solids contents of the concentrates obtained with total or partial discharge shows clearly that partial discharge gives the highest solids contents (total discharge, run 1, 8 w/o versus partial discharge, runs 2 - 9, 13 w/o). The apparent density of the concentrate as discharged was 800 ± 50 kg/m^3.

The theoretical amount of precipitate removed, calculated from the quantity of chemicals added and the mineral content of the water before and after treatment is 120 kg for the runs 2 - 9. This value corresponds with the amount of dry concentrate found, 125 kg, indicating that the precision of the data of Table II is acceptable.

- Interval between discharges. The given times are mean values calculated over the total time of each run. The moment of discharge was determined by visual inspection of in- and out-flow (see the Appendix).

- Volume reduction factor. These values are calculated from the volumes of water treated and of the resulting concentrates.

2.3. Costs of Operation

The complete installation of the separator costs Ȼ 10.000,-*) and can process sludges of a single coprecipitation treatment of up to 10 m^3/h.

*) 1 Ȼ = 1 European Currency Unit = 1 U.S. $.

TABLE II.

Results of the sludge treatment with a centrifugal separator. Unless otherwise stated, the total liquid flow rate is 2.5 m^3/h.
T.D. : Total discharge. P.D. : Partial discharge.

Run	Type of Operation	Flow to Separator	Sludge Level in Flocculator (m)[1]	Concentrate Solids Content (w/o)	Interval between Discharges (min)	Volume of Water Treated (m^3)	Volume of Concentrate (m^3)	Volume Reduction Factor
1	T.D.	-	-	8.0 ± 1.5	-	270	0.54	500
2	P.D.	0.35	1.6	11.5 ± 1.0	20	70	0.18	390
3	P.D.	0.2	1.4 - 1.5	14.5 ± 0.5	35	70	0.10	700
4	P.D.	0.2 - 0.4	1.3 - 1.4	12.0 ± 1.0	20	50	0.10	500
5	P.D.	0.4	1.4	13.2 ± 0.1	25	25	0.07	350
6	P.D.	0.2 - 0.35[2]	1.1 - 1.3	16.5 ± 0.5	25 - 15[2]	70	0.11	630
7	P.D.	0.5 - 0.8[3]	1.2 - 0.6[3]	12.0 ± 1.5	15	105	0.32	340
8	P.D.	0.55	1.6	12.0 ± 1.5	20	55	0.12	460
9	P.D.	0.25 - 0.35[2]	1.3 - 1.5	14.0 ± 0.2	30 - 20[2]	155	0.20	770
Total runs 2-9				13		600	1.20	500

1) Below overflow.

2) Run at two liquid flow velocities. First value for 2.5 m^3/h, second value for 3.5 m^3/h.

3) Run with liquid level variation.

A very conservative calculation of the costs of a 500-fold volume reduction of the water treated gives:

- Depreciation (5 y.)	₣ 2000,-
- Maintenance (10 %/y.)	1000,-
- Energy and various	200,-
- Man power (¼ labourer)	1000,-
Total per year	₣ 4200,-

A calculation of the costs per m^3 of water has only sense when the separator is employed full-time at its maximum flow rate. In this case, the costs will be ₣ 0.25/ m^3 for a yearly treatment of 16000 m^3 of effluent at 10 m^3/h.

3. CONCLUSIONS

The method described before has the following characteristics:

- The concentrate (see Pictures I and II) is of a consistency that excludes dust hazards. It is of compact nature and can easily be mixed with asphalt for final insolubilization.

- The removal of the sludge from the flocculator is continuous and the sludge level is easy to regulate.

- The treatment of the sludge is almost instantaneous. The quantity of sludge present in the processing units is as small as possible which reduces radiation hazards to a high degree. This is of importance when water of relatively high radioactivity is to be processed. Indeed, in such cases, the sludge can be evacuated immediately in quantities easily transportable without shielding. During the runs reported, the concentrate was usually transported in 60 - 100 l. batches having a radiation level of 10 - 200 mR/h (contact). During treatment of 10^{-3} - 10^{-2} C/m^3 (γ) containing water, it proved to be necessary to limit the transports to 10 - 15 l. each in order to keep the radiation level at a maximum of 200 mR/h (contact).

- The continuous withdrawal of sludge from the flocculator leads to a less dense heavy phase*) than intermittant withdrawal. This is of no importance since the filtered liquid is directly sent back to the flocculator. In this way a closed circuit is obtained that does not interfere with the open circuit of the water treatment itself (see Figure II). On the contrary, continuous withdrawal makes pH-regulation easy as the flow to the flocculator remains constant under all circunstances.

- Until now, the moment of discharge has been determined by visual inspection of the out- and in-flow. In future, the moment of discharge will be determined by foto-electric cells. This system, combined with automatic control and regulation of the pH as well as of the sludge-level in the flocculator, makes the whole water treatment process automatic.

---

*) Usually $\sim$ 0.6 w/o.

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APPENDIX

Description and Operation of the Centrifugal Separator.

The separator, made of 316 stainless steel, model De Laval CRPX 207-34 S, has a maximum throughput of 9 m^3/h for pure water, but optimally performs only at sludge throughputs less than 1 m^3/h. A schematic drawing is given in Figure III. The liquid enters at A, flows down the central passageway, around the lowest disc at B and upwards, clarified liquid leaving at D. Centrifugal force flings solids against the bowl wall C, where they accumulate in a 4 l. storage volume.

Cleaning of the sludge bowl proceeds by:

- Total discharge. The whole volume is discharged through the bowl slots at C with feed being shut off. In this way, some concentrate will also be discharged after only a short residence time.

- Partial discharge. By opening and closing the discharge ports so quickly that only a part, 2 - 2.5 l. of the bowl is discharged, a much denser product can be obtained. This can be done without feed shut-off.

The possibility of the use of a separator for sludge concentration was studied with a borrowed separator, equipped for "total discharge" (run 1). The definitively installed separator is equipped with an automatic partial discharge device (runs 2 - 9).

For satisfactory operation, two parameters had to be investigated:

- Interval between discharges. It was found that the most dense concentrates are obtained by discharge around (± 2 min) the moment where in- and out-flow are of equal composition. Premature discharge yields a watery concentrate, whereas prolonged thickening gives concentrates that are difficult to discharge.

- Duration of bowl discharge. Also here an optimal duration was to be found. In the case of sludges of the phosphate-types, duration of the whole discharge operation is optimally 11 seconds of which:

    - 4 sec. for preparation of opening,
    - 1 sec. discharge,
    - 6 sec. for closing of slots.

FIGURE I

FLOW SHEET OLD INSTALLATION

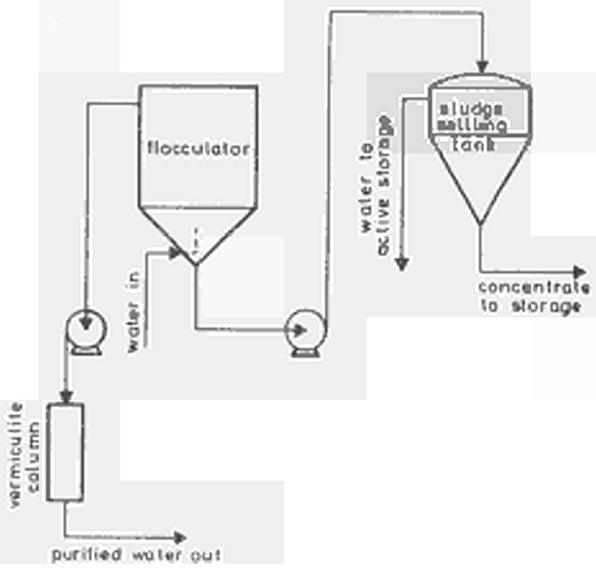
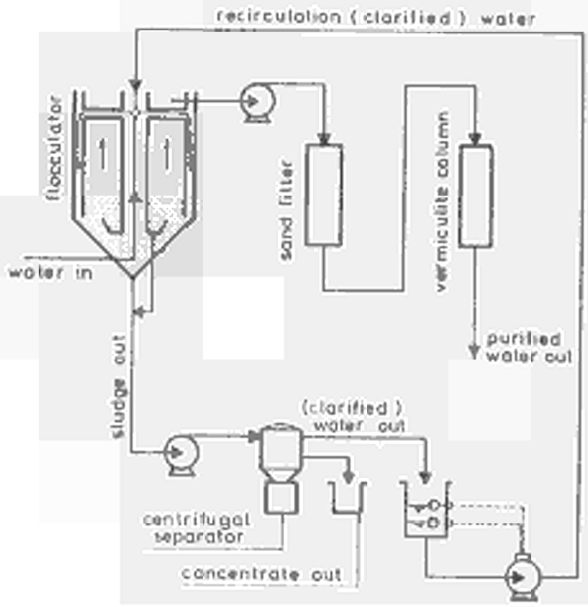


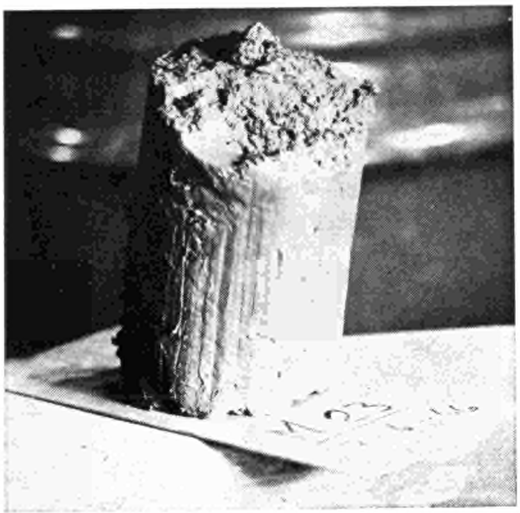
FIGURE II

FLOW SHEET ACTUAL INSTALLATION



PICTURE I

Top view of 100 l barrel
containing final concentrate (run 6).

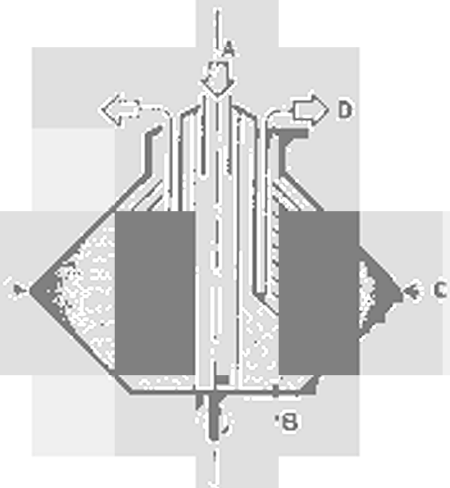


PICTURE II

View of one block of final
concentrate of dimensions
10 × 20 cm, containing 16.5
w/o solids (run 6).

FIGURE III

SCHEMATIC DRAWING OF CENTRIFUGAL SEPARATOR



liquid follows way A - B - D
solids follow way A - B - C

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Alfred Nobel

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