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Clean technologies

A MODIFICATION OF SIROFLOCK PROCESS UNDER DYNAMIC CONDITIONS

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Abstract. Experiments with the modified Siroflock process were carried out using a filter in a device filled with black sand containing significant quantity of magnetite. For comparison, the same experiments were carried out under similar conditions with filtering device filled with quartz sand (typically used as filtration material). The capacity of the quartz sand was found to be smaller than that of the black sand. Based on the results obtained, a conclusion was made that the Siroflock process is a positive alternative of the traditional methods for preliminary purification of water flows before ion-exchange demineralisation processes.

Keywords: Siroflock process, natural water, black sand, magnetite.

AIMS AND BACKGROUND

The Siroflock process was realised for the first time in Australia in 1985 and is used only as a part of the preparation of water for drinking. The classical process[1-4] involves introduction of powdery magnetite (particle size 1-10 μm) in water for 15 min under continuous agitation. Then the water is flown through an electromagnetic appliance. Further, the large agglomerates are separated into receptacles, the clarified water is sent to water supply system and the used magnetite is subjected to regeneration together with the sludge. The regeneration comprises treatment of the sludge with NaOH solution at pH 11-12, washing and separation of the magnetite by magnetic separators.

A modified Siroflock process was suggested[5] where the fine-powder magnetite was replaced by natural black sand rich in magnetite. This modification provides better possibilities for its implementation – the process can be carried out under dynamic conditions with filters filled with black sand. Thus, the water would be filtered through the black sand filtering material.

EXPERIMENTAL

With the present experiments, the modified Siroflock process was studied under dynamic conditions with black sand from the Black sea coast near Bourgas.

The black sand composition was determined by X-ray analysis (Fig. 1) using

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an IRIS-M apparatus (Germany). The X-ray patern was obtained by Cu, K_α radiation ($\lambda = 1.540$ Å) and Ni filter. The interplanar distances d (Å) were calculated and used to determine the sample composition. The main components found were SiO_2 (α-quartz) with characteristic interplanar distances 3.35 and 4.25 Å; magnetite (Fe_3O_4) with $d = 2.54$ Å, chematite (Fe_2O_3) with $d = 2.54$ and 2.69 Å), traces of aFe with $d = 2.02$ Å and some other ferrous compounds but the predominant component was magnetite.

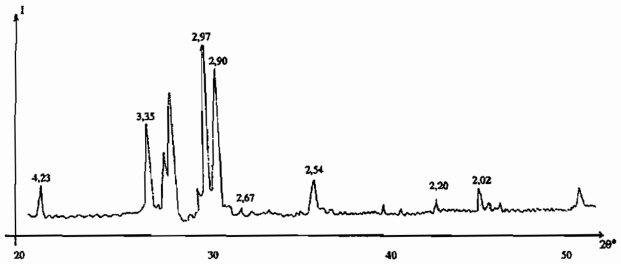

Fig. 1. X-ray diffractogram of black sand rich in magnetite

Since black sand (b.s.) played also the role of a filtering material, the most often used material for preparation of water for drinking – quartz sand (q.s.) – was studied for comparison. Both types of sand had the same granulometric composition since the fractions with particle size 0.8-1.0 mm were selected.

The experiments were carried out in:

– filter loaded with quartz sand;

– filter loaded with black sand rich in magnetite;

– filter comprising two layers: upper layer of quartz sand, and lower layer of black sand. Both layers were stratified immediately one over the other without a separator. From the filtering materials, black sand was with higher density due to magnetite content, therefore this was normal stratification of the filtering materials by back washing of the combined layer.

Water from Bourgas municipal water supply system was used for the experiments. Five filter-cycles were performed with each of the three fillers. The following characteristics were determined for both raw and clarified water: humic acids content, permanganate oxidability, content of suspended substances.

RESULTS AND DISCUSSION

The results obtained (Figs 2, 3, 4) (the data are from the 5th filter-cycle since they were almost identical to those from the preceding 4 cycles) showed that the quartz sand (which is the most widely used filtering material for water purification) retained to smaller extent the contaminants present in the treated water (so far as the characteristics studied are concerned – humic acids content, permanganate oxidability, content of suspended substances) compared to the other filtering material – black sand rich in magnetite. In both filters the contaminats were retained by the surface filtering mechanism – the retained in the upper layer mechanical contaminats form a new surface layer which becomes the main filtering element in the filter filling. Due to the densification of this new layer, the properties of the filtrate were found to improve during the filtering cycle, i.e. clear water with progressively decreasing contaminants content was obtained. In the black sand filter, however, neutralisation of the negatively charged colloid particles present in all natural waters and positively charged magnetite particles took place during the process, so magnetite can be regarded as coagulant. This is a kind of contact coagulation occurring in the grains of the black sand. Thus, the process took place not only in the upper filtering zone formed by the particles of the filtering material and retained dispersed substances (i.e. in the surface layer) but also on the surface of the black sand particles which play as nuclei and carriers for the $Fe(OH)_3$ formed.

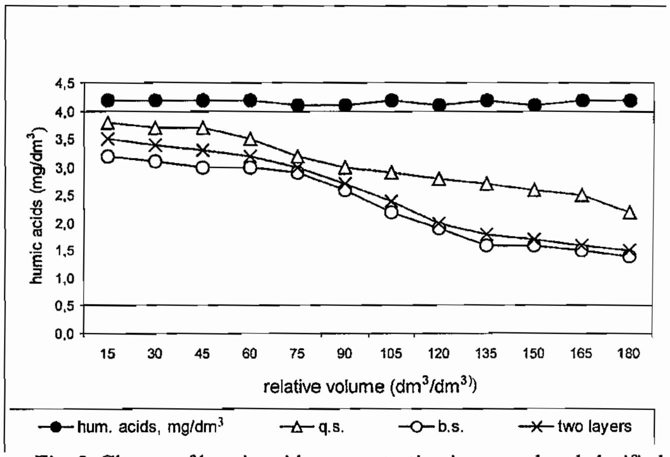

Fig. 2. Change of humic acids concentration in natural and clarified water during the filter-cycle

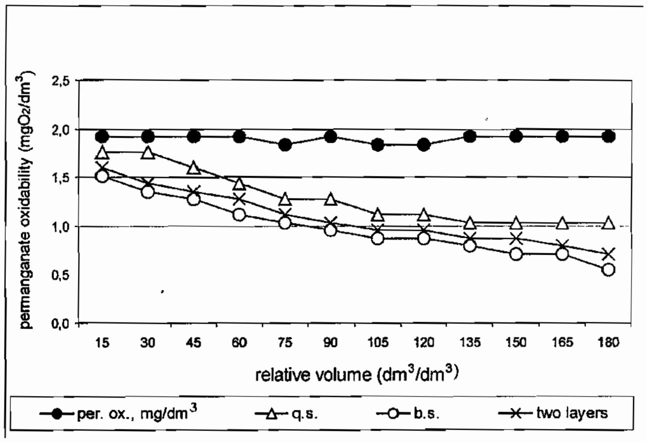

Fig. 3. Change of permanganate oxidability in natural and clarified water during the filter-cycle

The properties of the clarified water obtained from the two-layered filter were close to the properties of the water obtained from the filter filled with black sand.

With the realization of the Siroflock process discussed above, the release of the sludge retained by the filter was achieved by intense back washing of the filter without the use of other reagents.

The filtration capacity (FC) of the filtering materials used was calculated to be: (kg retained amount of suspended substances per 1 m^3 filtering material):

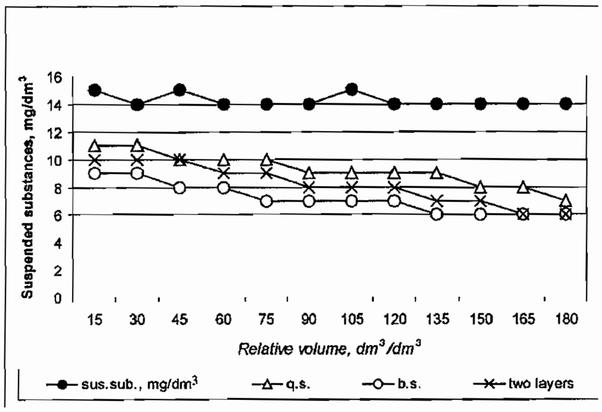

Fig. 4. Change of suspended substances concentration in natural and clarified water during the filter-cycle

– FC of quartz sand – 4.9 kg/m³;

– FC of black sand – 6.9 kg/m³;

– FC of combined filter – 6.0 kg/m³.

The FC of the two-layered filter calculated versus the suspended substances, as well the results for the other two characteristic values studied for the water obtained from the filter with two-layered filling were compared to those for water obtained from black sand filled filter. As a result, the filter filled only with black sand rich in magnetite was found to be the better alternative.

Table 1 shows the data for the decrease of the values studied for the water treated by the three variants of the Siroflock process[6,7]. It can be seen that the highest purification of the water was achieved with the Siroflock process performed under dynamic conditions. This process should be assessed technologically as the most suitable for application, most cost-effective and the best from ecological point of view due to the lack of necessity for reagent regeneration of the magnetite.

Table 1. Decrease of the parameters of the water studied by the Siroflock process

Variant of the Siroflock process	Process conditions	Decrease of (%)		
		humic acids	permanganate oxidability	suspended substances
1	2	3	4	5
Traditional variant[5]	with pure magnetite D_m=1.5 g/dm³	40.5	45.3	14.3
	pure magnetite + cat. act. flock F_o4400 D_m=1.0 g/dm³ D_{fl}=1.0 mg/dm³	42.3	44.6	46.7
Modified variant[6]	with inactivated black sand $D_{i.b.s.}$=2.0 g/dm³	30.4	31.2	18.8
	with activated black sand $D_{a.b.s.}$=2.0 g/dm³	30.0	36.2	20.0
	inactivated black sand + cat.act.flock. $F_0$4400 $D_{i.b.s.}$=2.0 g/dm³ D_{fl}=1.0 mg/dm³	57.9	48.9	43.8

to be continued

Continuation of Table 1

1	2	3	4	5
Modified variant under dynamic conditions	filter loaded with black of the sand, fraction 0.8-1.0 mm	Range of the decrease achieved with 100 and 180 rel.vol. of purified water		
		47.6-66.7	52.2-70.8	53.3-57.1

CONCLUSIONS

Based on the results obtained and discussed above, the modified Siroflock process studied (under dynamic conditions, with filter filled with black sand rich in magnetite, no additional reagents) can be suggested as an alternative to the well known reagent techniques for preliminary purification of waters.

REFERENCES

1. D. R. DIXON, A. J. PRIESTLEY: The Siroflock Process for Water Purification. Res. Pev. 1985 CSIRO DIV. Chem and Wood Technol., Melbourne, 1986, 13-23.
2. W. A. BOLTO, W. G. RAPER: Water Purification. Res. Pev. 1985 CSIRO DIV. Chem. and Wood Technol., Melbourne, 1986, 77-84.
3. R. GREGORY, J. MALONEY, M. STECKLEY, J. JUST: Water Treatment Using Magnetite. A Study of a Siroflock Pilot Plant. Water and Environ. Manag., **2**, 532 (1988).
4. D. R. DIXON: An Alternative Water Treatment Method Using Magnetite. GIT, **32**, 44 (1988).
5. St. PAVLOVA: Pretreatment of Natural Water for Ion-exchange or Membrane Demineralization by Siroflock Process. In: Proc. of II Int. Symp. "Ecology '93", Bourgas, 1993, 241-247.
6. Iv. DOBREVSKY, St. PAVLOVA: A Modificated Variant of Siroflock Process for Natural Water Treatment. In: Proc. of XI Int. Symp. "Ecology '02", 2002, Bourgas.

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