Evaluation of the effectiveness of hydrogen sulphide removal in a biotrickling filter

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INTRODUCTION

Hydrogen sulphide is an air pollutant emitted as a result of the activities of municipal management facilities such as wastewater treatment plants, waste treatment plants, as well as industrial facilities - e.g. pulp and paper or sugar industries. Due to the low olfactory detection threshold and the unpleasant, irritating nature of the smell, H_2S largely contributes to the odor nuisance. Gases containing H_2S can be purified by traditional physical and chemical methods, but for economic reasons and due to the problem of secondary waste generation, it seems beneficial to use biological methods, including biotrickling filtration. The paper presents the evaluation of the effectiveness of H_2S removal on a lab-scale biotrickling filter packed with open pore polyurethane foam.

BIODEGRADATION OF H_2S:

Oxic:

$$H_2S + 2O_2 \rightarrow SO_4^{2-} + 2\,H^+$$

$$HS^- + \tfrac{1}{2}\,O_2 \rightarrow S^0 + H_2O$$

$$S^0 + H_2O + \tfrac{1}{2}\,O_2 \rightarrow SO_4^{2-} + 2\,H^+$$

$$\tfrac{1}{2}\,S_2O_3^{2-} + \tfrac{1}{2}\,H_2O + O_2 \rightarrow SO_4^{2-} + H^+$$

Unoxic:

$$5\,H_2S + 8\,NO_3^- \rightarrow 5\,SO_4^{2-} + 4\,N_2 + 4\,H_2O + 2\,H^+ \quad (N/S = 1.6)$$

$$5\,H_2S + 2\,NO_3^- \rightarrow 5\,S^0 + N_2 + 4\,H_2O + 2\,OH^- \quad (N/S = 0.4$$

$$H_2S + 4\,NO_3^- \rightarrow SO_4^{2-} + 4\,NO_2^- + 2\,H^+ \quad (N/S = 4)$$

$$H_2S + NO_3^- \rightarrow S^0 + NO_2^- + H_2O \quad (N/S = 1)$$

$$12\,H_2S + 15\,NO_3^- \rightarrow 6\,S^0 + 6\,SO_4^{2-} + 5\,N_2 + 5\,NO_2^- + 9\,H_2O + 2\,OH^- + 4\,H^+$$

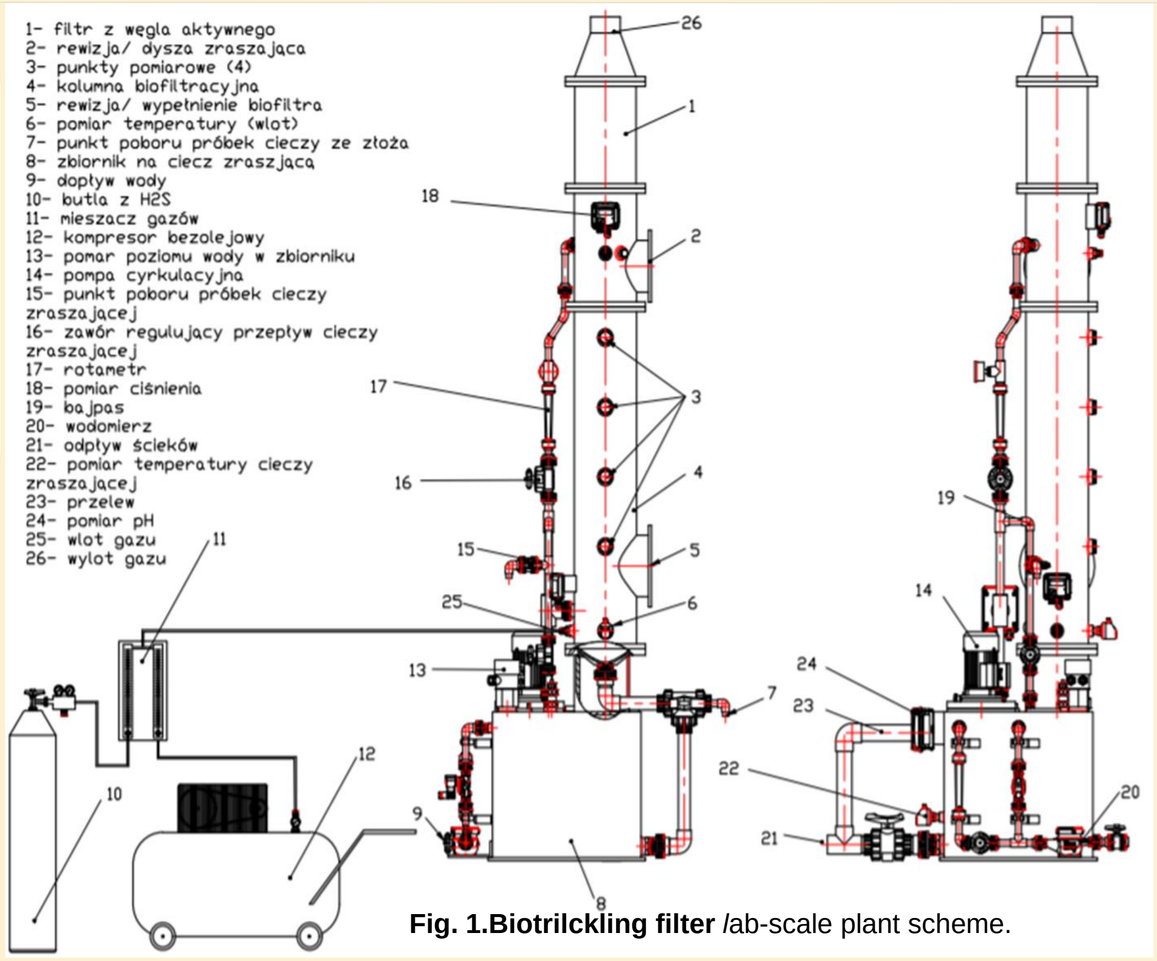

Fig. 1.Biotrilckling filter /ab-scale plant scheme.

The BTF packed with open pore PUF foam (the properties of the filter material are shown in Table 1), with a column height of 0.88 m and a diameter of 0.22m, inoculated with pre-thickened activated sludge from a local WWTP, was operating with counter-current flows of the air and liquid streams by 3 series of measurements. During these tests, daily measurements of H_2S concentration in gas at the inlet to the biofilter and at 5 measuring points responding to EBRT= 9.4s, 19.6s, 29.7s, 39.8s and 44.3s were carried out using a portable biogas analyzer (Nanosens DP-28 bio) with a measuring range of H_2S 0-2000 ppm.

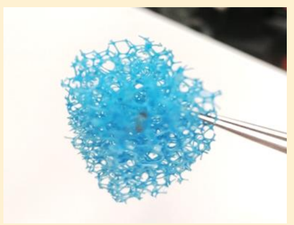

Fig. 2. A single element of the filter bed.

Tab. 2. Properties of the filter material.

Properties	
Material	Open-pore polyurethane foam
The size of a single element	15mm x 15mm x 15mm
Density	25 kg/m^3
Type	PPI10 (10 pores/inch, 97% pores open

RESULTS AND DISCUSSION

After the adaptation stage of the filter bed, III measurements series were carried out, lasting 10, 15 and 8 days, respectively, during which gases with concentrations of 59÷65 ppm, 116÷128 ppm and 169-181 ppm of H_2S were subjected to the biotrickling filter, respectively. In each of them, the effectiveness of H_2S removal was assessed for 5 different gas retention times from 9.4 s to 44.3 s. Results indicated that even at the EBRT 9.4 s, the efficiency of H_2S removal on the biotrickling filter was up to 98.4% 91.4% and 95.9% for the inlet H_2S concentration of 59÷65 ppm, 116÷128 ppm and 169-181 ppm respectively.

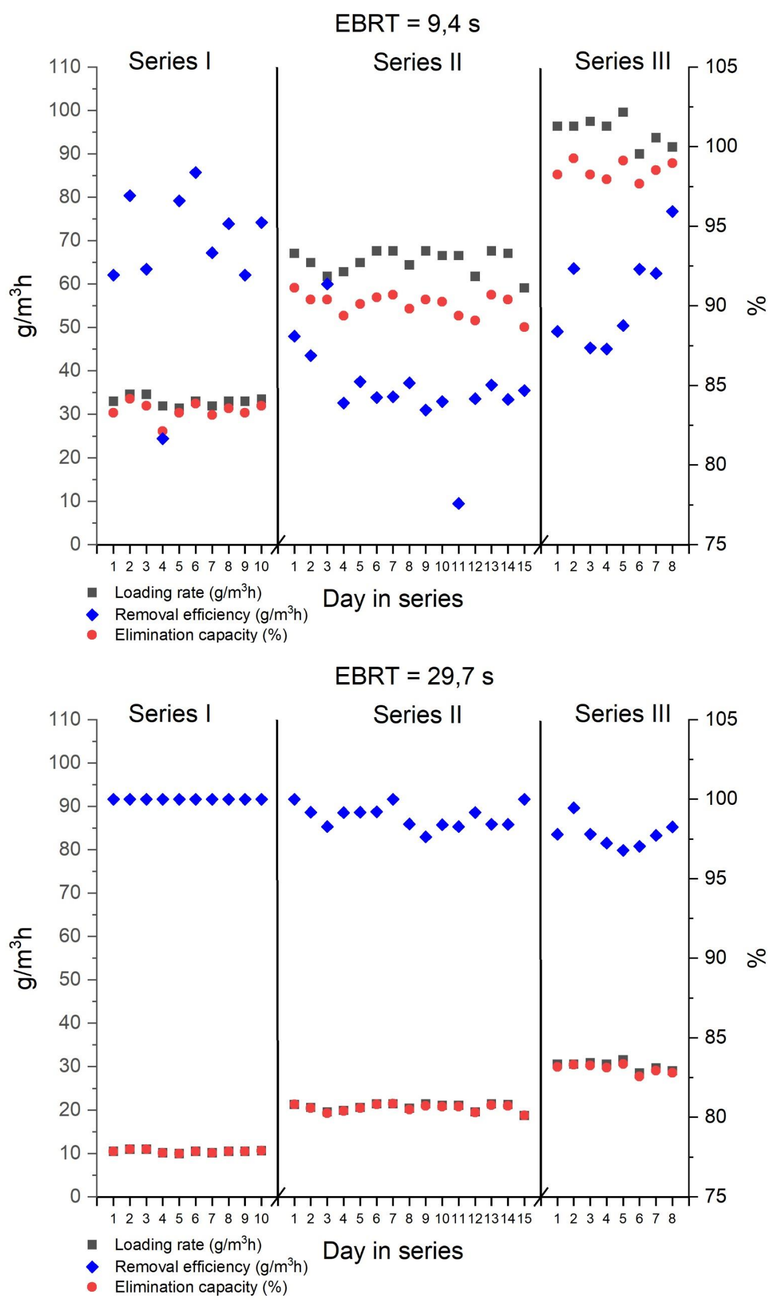

Fig. 3-7. H_2S loading rate, elimination capacity and removal efficiency in lab-scale biotrickling filter plant for series I, series II and series III and EBRT = 9.4s, 19.6s, 29.7s, 39.8s and 44.3s..

Tab. 3. Process parameters during Series I, Series II and Series III.

Parameters	Series I	Series II	Series III
H_2S loading rate, g/m^{3}h	6,69-7,37	12,58-14,40	19.16-20.74
Inlet H_2S concentration, ppm	59-65	116-128	169-181
Gas flow, dm^3/min	40,0	40,0	40,0
Liquid flow, dm^3/h	30,0	30,0	30,0
Liquid pH range	6.9-1.9	6.4-1.1	1,5-5,1
Liquid conductivity range, mS/cm	0.6-8.6	0.6-19.6	0,8-21,5
Liquid temperature range, ^{O}C	17.6-23.10	12.7-23.9	21,4-28,1
Gas temperature range, ^{O}C	16.1-26.7	14.9-25.7	18,3-24,5

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