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# THE TREATMENT OF MANURE WITH THE USE OF PRESSURE-DRIVEN MEMBRANE TECHNIQUES

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Abstract

**High-density livestock farming causes many difficulties connected with proper management of produced manure. The application of membrane technologies seems to be an attractive solution to this problem. It enables to obtain concentrated nutrients solutions and also recovery of proper quality water which can be further reuse on a farm, what would be a great advantage in areas, where water deficiency takes place.**

**The aim of the study was to determine the effectiveness of integrated centrifugation and two-step-ultrafiltration processes used as manure pretreatment before reverse osmosis. The final permeate obtained during the process was characterized by significantly lower values of parameters like: ChZT, $BZT_5$, OWO, WN, OW, $N\text{-}NH_4^+$, $PO_4^{3-}$ . However, it still required further treatment via reverse osmosis.**

Streszczenie

**Wielkoprzemysłowa hodowla zwierząt stwarza wiele trudności z odpowiednim zagospodarowaniem produkowanej gnojowicy. Zastosowanie technologii membranowych wydaje się atrakcyjnym rozwiązaniem tych problemów. Z jednej strony stwarza możliwości otrzymywania wysoce skoncentrowanych produktów nawozowych, z drugiej zaś pozwala na odzysk odpowiedniej jakości wody, która mogłaby być ponownie wykorzystana w miejscu hodowli. Odzysk wody byłby szczególnie korzystny w obszarach, które borykają się z jej niedoborem.**

**Celem przeprowadzonych badań było określenie efektywności zintegrowanych procesów wirowania i dwustopniowej ultrafiltracji jako etapu wstępnego przygotowania gnojowicy przed procesem odwróconej osmozy. Otrzymany w końcowym etapie permeat charakteryzował się znacznie niższymi wartościami parametrów jak: ChZT, $BZT_5$, OWO, WN, OW, $N\text{-}NH_4^+$, $PO_4^{3-}$ w odniesieniu do surowej gnojowicy.**

Keywords: **Pig manure; Membranes; Ultrafiltration; Centrifugation; Water recovery.**

## 1. INTRODUCTION

High-density livestock farming causes many difficulties with proper management of produced manure [1]. Generally, two main methods are used for this purpose: the manure is used as a fertilizer and directly disposed on fields or it is treated as sewage and drained to surface waters [2]. Local distribution of farming areas unables the in-situ utilization of the whole produced manure [3]. On the other hand, the transportation of manure requires significant money outlays. The application of membrane technologies seems to be proper solution for the manure management problems [4]. It enables to obtain highly-concentrated fertilizing products as well as to recover the proper quality of water which can be reused on farms [5]. The

**Figure 1.**
**The lagoon for manure collection and storage**

reclamation of water would be a great advantage in areas, which deal with its deficit [6].

## 2. THE AIM OF THE STUDY

The study aimed to determine the effectiveness of integrated centrifugation and two-step ultrafiltration processes as a preliminary treatment before reverse osmosis process. Two types of ultrafiltration membranes were used: polivinylidene fluoride (PVDF) membrane of cut-off 100 kDa and poliethersulfone (PES) membrane of cut-off 5 kDa. Parameters like: pH, COD, $BOD_5$, TOC, IC, TC, $N\text{-}NH_4^+$ and $PO_4^{3-}$ were analyzed in all streams produced during the process.

## 3. THE METHODOLOGY OF THE STUDY

The swine manure produced in one of the larger farms in Silesia was used during the study. The 50 $dm^3$ sample was taken from the lagoon of total volume 13000 $m^3$ which is localized on farm (Fig. 1).

The crude manure was firstly centrifuged for 15 min with the rotational speed of 20000 rpm. The obtained supernatant in the amount of 500 $cm^3$ was then placed in the feed tank of the laboratory membrane filtration apparatus KMS Laboratory Cell CF1 (by KOCH). The scheme of the apparatus is presented in Fig. 2.

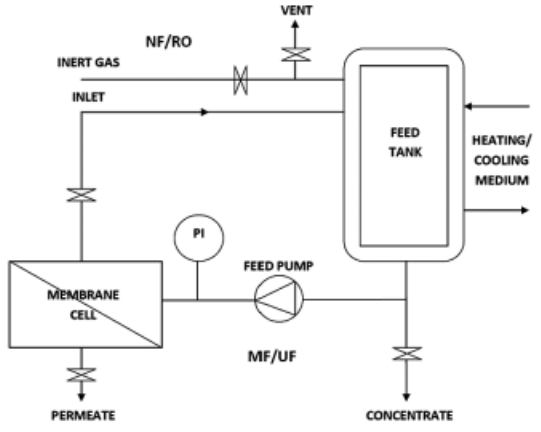


**Figure 2.**
**The scheme of the ultrafiltration apparatus KMS Laboratory Cell CF1 (by KOCH)**

The unit is equipped with the feed tank of 500 $cm^3$ volume and works in the cross-flow system. The membrane cell is adapted for flat membranes of effective filtration area equal 28 $cm^2$. The supernatant obtained during centrifugation was introduced into the filtration apparatus. The UF PVDF membrane of cut off 100 kDa was installed in the membrane cell. The first step UF process was carried out under the pressure of 0.3 MPa. The obtained permeate acted as a feed for the second step UF. The UF PES membrane of cut off 5 kDa was used. The pressure during the process was kept at the level of 0.5 MPa. The scheme of particular streams flow during the process is displayed in Fig. 3.

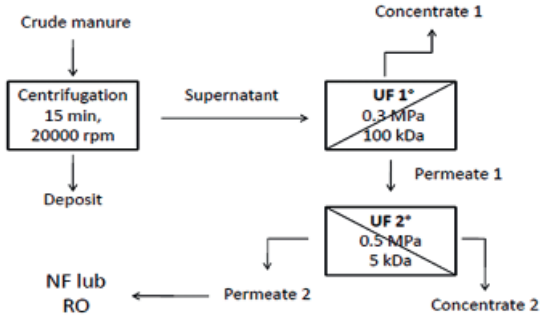


**Figure 3.**
**The scheme of produced streams flow during the treatment process**

The analysis of the streams produced during the process covered the change of parameters like: pH, COD, $BOD_5$, TOC, IC, TC, $N\text{-}NH_4^+$ and $PO_4^{3-}$. COD and ammonium nitrogen concentration were measured according to Merck methodology, while $BOD_5$ by means of the respirometric method with the use of OXI Top WTW set. The concentration of phosphate ions was determined via ionic chromatography using DX 120 chromatograph by Dionex. The content of particular forms of carbon was analyzed on Multi N/C analyzer by Jena Analytic.

## 4. RESULTS AND DISCUSSION

The study revealed that the integrated centrifugation and two-step ultrafiltration processes were efficient for pretreatment of manure before reverse osmosis. The parameters of particular streams produced during the whole process are presented in table 1. The permeate obtained in the second-step ultrafiltration could be directly treated via RO.

The centrifugation process allowed to decrease the content of organic impurities expressed as COD and $BOD_5$. The concentration of phosphate ions was also significantly lower.

Further treatment of the supernatant from centrifugation process via two-step ultrafiltration resulted in further decrease of organic impurities content. The color and turbidity of the treated manure were much improved.

The total decrease of COD and BOD5 was equal 56% for both. The content of phosphate ions in final permeate was 75% lower than in the crude manure. The ammonium nitrogen concentration was decreased by 20%.

The permeate streams in both UF processes were significantly smaller than ones obtained during filtration of deionized water. The comparison of streams of deionized water and both permeates is shown in fig.4

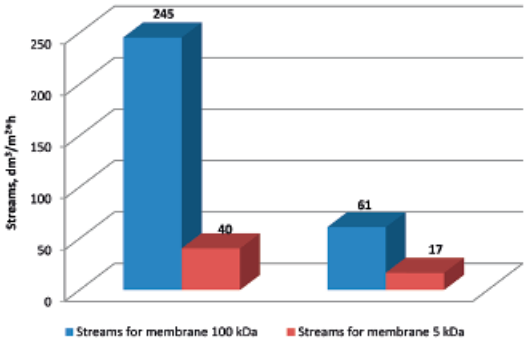


**Figure 4.**
**Comparison of streams obtained during filtration of deionized water and manure**

**Table 1.**
**The parameters of the streams produced during the treatment process**

| Parameter | Unit | Crude manure | Supernatant | Permeate 100 kDa | Concentrate 100 kDa | Permeate 5kDa | Concentrate 5kDa |
|---|---|---|---|---|---|---|---|
| pH | - | 7.65 | 7.65 | 7.89 | 7.87 | 8.06 | 8.01 |
| $BOD_5$ | $mgO_2/dm^3$ | 18000 | 9000 | 8000 | 11000 | 8000 | 11000 |
| COD | $mgO_2/dm^3$ | 54575 | 32300 | 25200 | 37200 | 24000 | 33700 |
| TOC | $mg/dm^3$ | 5941 | 3340 | 1990 | 3758 | 1682 | 3659 |
| IC | $mg/dm^3$ | 1318 | 1566 | 1149 | 1055 | 530 | 1097 |
| TC | $mg/dm^3$ | 7259 | 4906 | 3139 | 4813 | 2784 | 4756 |
| $N\text{-}NH_4^+$ | $mg/dm^3$ | 3850 | 3650 | 3000 | 3550 | 3075 | 3425 |
| $PO_4^{3-}$ | $mg/dm^3$ | 828 | 231 | 211 | 596 | 175 | 483 |

It was observed that the permeate stream in the first step UF was decreasing with time. It was probably caused by the membrane fouling and the deposition of the impurities on the membrane surface. During the second step of UF this phenomenon was negligible. The change of the permeate streams for both membranes is shown in fig. 5a and 5b.

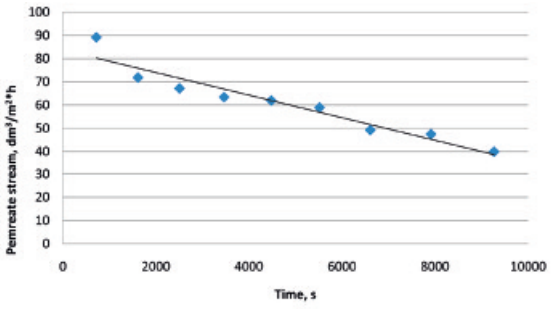


**Figure 5a.**
**Change of permeate streams in time for membrane 100kDa**

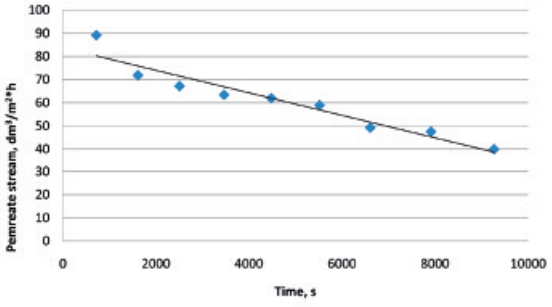


**Figure 5b.**
**Change of permeate streams in time for membrane 5kDa**

## CONCLUSIONS

The study revealed that:

- the integrated process of centrifugation and two step ultrafiltration allow to significantly decrease the content of organic impurities and phosphate ions
- the color and turbidity of the treated manure were much improved
- the total recovery degree equal 70%, and the final permeate requires further treatment via nanofiltration or reverse osmosis process
- in both UF steps the decrease of permeate streams is observed, however it is more significant in the first step.

## ACKNOWLEDGMENTS

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