

CONTENT OF MAGNESIUM AND OTHER FERTILIZER COMPOUNDS IN STABILIZED AND DEWATERED SEWAGE SLUDGE FROM THE MUNICIPAL SEWAGE TREATMENT PLANT IN RECZ

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Abstract

The aim of this study was to determine the content of magnesium and other fertilizer compounds (Ca, K, Na, P, N and S) in stabilized and dewatered sewage sludge stored on dewatered sites at the Municipal Treatment Plant in Recz in 1994-2003. Discharge of post galvanic sewage to the municipal sewer system was evaluated at approximately 10% processed sewage at this treatment plant. The fertilizer value and possible utilization of the sludge was evaluated.

When evaluating possible use of the sewage sludge for fertilization purposes in agriculture, it was found that the concentration of magnesium in sludge samples was in the range of 0.2-0.5, on average 0.33%, and was substantially lower than the level of this compound given in literature. The content of this compound in sewage sludge is found in the range 0.02 do 7.6% and depends on the type of a treatment plant, treatment process, and also on the share of industrial sewage. Sewage sludge applied in agriculture should be characterized by a high content of magnesium (approximately 0.6%).

Some physical and chemical properties of the examined sewage sludge were very good (loose soil consistency, lack of odor, humidity from 40 to 80%, suitable pH and high concentration of Ca, K, Na, P, N and S).

The reaction was in the pH range from 5.6 to 7.0 (from slightly acid to neutral), which is typical of sewage sludge obtained during the biological processing of municipal sewage.

The mean content of main nutrient compounds in the sludge, which was N – 2.7%, P – 4.7 and K – 0.18%, enables classification of this material as suitable for use in agriculture.

Taking under consideration the content of all macronutrients and physical properties of the sludge produced at the Municipal Treatment Plant in Recz, it can be concluded that this sewage sludge may be applied on agricultural land and used for reclamation of degraded soils. But every batch of sewage sludge should be analyzed and evaluated individually because it may contain excessive amounts of heavy metals due to periodical discharge of post galvanic sewage to municipal sewerage.

Key words: magnesium, nutrient compounds, post galvanic sewage, sludge, utilisation.

ZAWARTOŚĆ MAGNEZU I INNYCH SKŁADNIKÓW NAWOZOWYCH W USTABILIZOWANYCH I ODWODNIONYCH OSADACH ŚCIEKOWYCH Z MIEJSKIEJ OCZYSZCZALNI ŚCIEKÓW W RECZU

Abstrakt

Celem pracy było określenie zawartości magnezu i innych składników nawozowych (Ca, K, Na, P, N i S) w ustabilizowanych i odwodnionych osadach ściekowych zgromadzonych w latach 1994-2003 na kwaterach odwadniających Miejskiej Oczyszczalni Ścieków w Reczu, do której dopływa ok. 10% ścieków galwanicznych. Ponadto zdefiniowano wartość nawozową tych osadów oraz możliwości ich wykorzystania.

Oceniając przydatność badanych osadów ściekowych do celów nawozowych, stwierdzono, że w przebadanych próbkach koncentracja Mg była niższa niż zawartość tego pierwiastka podawana w literaturze i wynosiła 0,2-0,5% średnio 0,3%. Zawartość tego pierwiastka w osadach ściekowych zależy od rodzaju oczyszczalni ścieków, sposobu oczyszczania, a także ilości ścieków przemysłowych, i może wynosić od 0,02 do 7,6% s.m. W osadach ściekowych wykorzystywanych w rolnictwie jako nawóz jest zazwyczaj wysoka (ok. 6% s.m.) zawartość magnezu.

Badane osady charakteryzowały się bardzo dobrymi właściwościami fizycznymi, były bowiem sypkie, ziemiste i prawie zupełnie bezzapachowe, o uwilgotnieniu od 40 do 80%, miały odpowiedni odczyn i dużą zawartość Ca, P i S. Ich odczyn – od lekko kwaśnego do obojętnego (pH od 5,6 do 7,0) – był typowy dla osadów ściekowych powstających podczas biologicznego oczyszczania ścieków komunalnych. Średnia zawartość podstawowych składników pokarmowych w osadach (N – 2,7%, P – 4,7% K – 0,18%) pozwala na zaklasyfikowanie ich do grupy osadów ściekowych nadających się do stosowania w rolnictwie. Biorąc pod uwagę zawartość wszystkich makroskładników oraz ich cechy fizyczne, osady z miejskiej oczyszczalni ścieków w Reczu mogą być wykorzystywane na cele rolne i rekultywacyjne, pod warunkiem jednak, że każdą partię tych osadów należy przebadać pod kątem zawartości metali ciężkich ze względu na dopływ do oczyszczalni ścieków pogalwanicznych.

Słowa kluczowe: magnez, składniki pokarmowe, osad ściekowy, ściek pogalwaniczny, wykorzystanie.

INTRODUCTION

Amount of sewage sludge emerging from treatment plants depends on the sewage composition, manner and degree of their treatment and time

of organic matter decomposition during the sludge stabilization process. But it also depends on the hydration degree of sewage sludge.

In 2000-2007, amounts of sewage sludge produced in municipal treatment plants steadily increased, which can be directly attributed to the increasing length of sewer network in our country and constantly growing households and industrial plants served by sewage treatment plants (GUS 2005). It is easy to foresee that production of sewage sludge will continue to grow in the next years.

Many authors pointed out that specific characteristics of sewage sludge depend on a number of factors such as the kind of treated sewage, technology of sewage treatment and manner of sludge stabilization (OUTWATER 1994, IMHOFF, IMHOFF 1996, KALEMBASA, KALEMBASA 1997, SADECKA, JĘDRCZAK 2004). These authors underline that increasing quantities of permanently produced sewage sludge are a perfect fertilized material, which may be applied on agricultural land and used for reclamation of degraded soils, simultaneously decreasing their amounts dumped on landfills.

According to the Polish legislation (*Ustawa o odpadach...* 2001), municipal sewage sludge can be used if it is stabilized and appropriately prepared for the purpose of use. Such preparation involves biological, chemical and thermal processing sewage sludge or other processes which reduce susceptibility of sewage sludge to putrefaction and eliminate threats posed by such material to environment or human health. The most popular method of using sewage sludge in Poland is its utilization on agricultural land.

It is often emphasised in literature that the fertilizer value of municipal sewage sludge is conditioned mostly by its content of organic matter, nitrogen, phosphorus and trace elements. The presence of these compounds is necessary for the proper development of plants and animals. (MAZUR 1996, BARAN et al. 1999, GAMBUŚ 1999, JOHANSSON et al. 1999, BORUSZKO et al. 2000). It is also important when making a decision on how to use particular batches of sewage sludge.

The aim of this study was to determine the content of magnesium and other fertilizer compounds (Ca, K, Na, P, N and S) in stabilized and dewatered sewage sludge stored on dewatered sites at the Municipal Treatment Plant in Recz in 1994-2003. The fertilizer value of the sludge as well as possibilities of its utilization were evaluated.

MATERIALS AND METHODS

Twenty four composite samples of stabilized and dewatered sewage sludge stored on dewatered sites at the Municipal Treatment Plant in Recz in 1994-2003 were collected from the depth 0-20 cm for further analysis using Egner's sampler.

Composite sample (ca 1 kg) of fresh materials were dried and crushed in a laboratory mortar and than sieved through a 1 mm sieve. The amount of 1 g of air dry sewage sludge was digested in a microwave in a mixture of concentrated nitric and perchloric acids at a ratio 3:1 (V / V) and with addition of 30% perhydrol for further analysis of macroelements (Mg, K, Na, Ca, S). Nitrogen and phosphorus were determined using the wet mineralization method in open configuration with sulphur acid.

The reaction, electric conductivity, content of organic matter and moisture in fresh samples of stabilized and dewatered sewage sludge were also determined. The employed methods are shown in Table 1.

In every analysis a test of blind samples was conducted as the control of all results.

Table 1

Range of analysis and applied methods of sewage sludge samples

Analysed materials	Range of analysis	Methods of analysis
Stabilized and dewatered sewage sludge	fresh samples of sewage sludge	
	pH	potentiometrically, using combine glass electrodes
	conductivity	conductometrically using combine graphite electrodes
	moisture	using of radwag measure with direct lecture of moisture
	contents of organic matter	method of dry incinerating in 450°C in a muffle oven
	air dry samples of sewage sludge	
	phosphorus and sulphur	colorimetrically with use of a Marcel Media Eko spectrometer
	potassium and sodium	flame emission photometry using a Solaar Unicam 929 spectrophotometer
	calcium and magnesium	atomic absorption using a Solaar Unicam 929 spectrophotometer
	nitrogen	distillation method with use of a Vapodest 30 by Gerhardt

RESULTS AND DISCUSSION

Stabilized sewage sludge stored in years 1994-2003 on dewatering sites in amounts ca 265 Mg d.m. manifested very good physical properties. This material, as indicated by the results presented in Table 2, was loose, looked

like earth, was odourless and had a moisture content in the range 40 to 80%. These properties of sludge substantially differ from the ones reported in literature (stickiness, odour, formation of clods during drying) (BIEŃ 2002).

The reaction of the tested sewage sludge was from slightly acidic to neutral (pH 5.6-7.0) and typical of sludge produced during the biological treatment of municipal sewage (SEBASTIAN, SZPADT 1999. KALISZ et al. 2000). The electric conductivity widely ranged from 0.1 to 4.1, on average 2.25 mS cm⁻¹, and showed substantial variability (V 58%).

The evaluation of the electric conductivity of salinity of water suspension prepared from the sewage sludge shows that most of the sewage samples contained a toxic level of salinity (1 g NaCl·dm⁻³) for majority of cultivated crops.

Noteworthy is the fact that the content of organic matter in the sewage sludge samples from the Municipal Treatment Plant in Recz is high, ranging from 40.0 to 59.7%, on average 53.5%, (Table 2) and shows only small differences between individual samples (V-9%), which proves that it has good fertilizer properties.

Table 2

Basic parameters of selected properties of stabilized and dewatered sewage sludge samples from the Municipal Treatment Plant in Recz collected in years 1994-2003

<i>n</i> = 24	pH (H ₂ O)	Conductivity (mS·cm ⁻¹)	Salinity (g NaCl·dm ⁻³)	Moisture (%)	Content of organic matter (%)
<i>x</i>	6.3	2.25	1.4	60.2	53.5
Min	5.6	0.1	0.7	39.6	40.0
Max	7.0	4.3	2.4	79.0	59.7
S	0.5	1.25	0.4	10.3	4.6
V (%)	7.3	55.7	31.5	17.1	8.6

As show in Table 3, the sewage sludge samples from the Municipal Treatment Plant in Recz was characterized by a high content of nitrogen, sulphur and phosphorus but the content of magnesium (0.2-0.5, on average 0.3%) was substantially lower than given in literature.

The studies conducted by BIEŃ (2002) and BIEŃ et al. (2002) showed a high content of calcium and very low magnesium in municipal sewage sludge. These authors pointed out that concentration of these macronutrients mainly depended on the kind of discharged industrial sewage. In some cases the content of calcium in sewage sludge exceeded 10% of d.m., with an average of 2-4%, while the content of magnesium was in the range 0.1 to 1.8% d.m. In sewage sludge from medium size sewage treatment plants the content

Table 3

Contents of fertilizer components in stabilized and dewatered sewage sludge samples from the Municipal Treatment Plant in Recz

$n = 24$	N	P	K	S	Mg	Na	Ca
	(%)						
x	2.7	4.7	0.18	2.8	0.3	0.06	1.5
Min	1.3	1.9	0.08	1.8	0.2	0.02	0.9
Max	3.7	6.1	0.24	4.8	0.5	0.11	2.3
S	0.5	1.0	0.04	0.9	0.07	0.02	0.4
V (%)	19.8	21.8	21.9	31.6	22.0	33.9	23.96

of magnesium ranged from 0.02 up to 7.6% d.m. and was similar to the range of the magnesium content (0.2 to 0.5%, on average 0.3%) in sewage sludge from the Municipal Treatment Plant in Recz.

The low content of magnesium in the sewage sludge examined may have resulted from some disturbance of the treatment process caused by periodical inflow of insufficiently purified post galvanic sewage to the treatment plant. This discharge of technological sewage to the municipal sewerage system substantially affected the efficiency of the treatment process caused by excessively high concentrations of heavy metals in the influx of post galvanic sewage.

KALEMBASA and KALEMBASA (1997) as well as GAMBUS (1999) emphasise that the content of magnesium in sewage sludge applied on agricultural land as fertilizer should usually be higher (ca 6%). Consequently, the examined sewage sludge with the maximum content of magnesium equal 0.5% is not good as fertilizer and cannot be qualified as material potentially used for agricultural purposes.

There are no substantial differences between the properties of sewage sludge samples from the Municipal Treatment Plant in Recz and sludge from other municipal treatment plants (WANG et al. 2005, KALISZ et al. 2000). Such a comparison reveals mainly the similarity of the chemical composition of the sludge from the Municipal Treatment Plant in Recz, especially its pH, content of organic matter and total nitrogen to the sludge examined by PIOTRKOWSKA and DUTKA (1987). However, the former has a considerably higher content of phosphorus and lower concentrations of calcium, magnesium, potassium and sodium.

The content of nitrogen and phosphorus found in sewage sludge samples from the Municipal Treatment Plant in Recz is relatively high and similar to the content of these compounds in composts produced from waste plant residues (KOKOT, ZABŁOCKI 2003) or compost produced with addition of sewage sludge (CZEKAŁA 2000, BARAN 2004, OLESZCZUK 2006) or the content

of these fertilizer compounds given by BOJANOWSKA et al. (1982), PIOTRKOWSKA and DUTKA (1987) and MERRINGTON et al. (2003).

These findings confirm the high fertilizer value of stabilized and dewatered sewage sludge samples from the Municipal Treatment Plant in Recz, mainly because of their high content of nitrogen, phosphorus, organic matter and very good physical properties. Such sewage sludge, although low in magnesium, may successfully be used in agriculture and for reclamation of degraded sites.

Despite all positive characteristics of dewatered sewage sludge, such material is often excluded from application in agriculture because of its high content of heavy metals, which cause contamination of environment, especially soil. Thus, every batch of sludge from the Municipal Treatment Plant in Recz, before it is used in agriculture or for reclamation purposes, should be analyzed to ensure that its content of heavy metals is not excessive.

In addition, the Municipal Treatment Plant in Recz periodically receives industrial sewage, which excludes the use of generated sewage sludge from agricultural utilization because of the high concentrations of heavy metals.

CONCLUSIONS

1. The tested sewage sludge was characterized by very good physical properties (loose soil consistency, lack of odour, moisture from 40 to 80%), suitable pH from 5.6 to 7.0 and high concentration of C, Ca, P and S. The pH ranged from 5.6 to 7.0 (from slightly acidic to neutral), which is typical of sewage sludge obtained during the biological processing of municipal sewage. The content of C, Ca, P and S was high.

2. The concentration of magnesium in sludge samples was 0.2-0.5 (mean 0.33%), and was substantially lower than the level of this compound given in literature.

3. The mean content of the main nutrients in the sludge, N – 2.7%, P – 4.7% and K – 0.18%, means that this material is suitable for use in agriculture.

4. Considering the content of all macronutrients and physical properties of the sewage sludge produced at the Municipal Treatment Plant in Recz, this sewage may be applied on agricultural land and used for reclamation of degraded soils.

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