Mineral and Energy Economy Research Institute
Polish Academy of Sciences

INVENTORY OF THE SECONDARY SOURCES OF THE BIOGENIC RAW MATERIALS IN THE CONTEXT OF THE CIRCULAR ECONOMY (CE) IMPLEMENTATION IN THE FERTILIZER SECTOR

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LINEAR ECONOMY

CIRCULAR ECONOMY

WASTE AS A SOURCE OF BIOGENIC RAW MATERIALS

WHAT NUTRIENTS CAN BE EXTRACTED FROM WASTE ?

Activities in the field of waste utilization for fertilising purposes is one of the key elements in the further development of the circular economy, which is the EU's economic priority.

Municipal waste

Industrial waste

Agricultural waste

...as a source of secondary raw materials

Municipal waste

- household waste
- food waste
- green waste
- digestion
- sewage sludge
- sewage sludge ash

Industrial waste

- biomass ash
- digestion
- sewage sludge from industrial plants

Agricultural waste

- animal waste
- plant waste

HOUSEHOLD WASTE

glass
paper and cardboard
packaging waste
plastics
biodegradable waste

Household waste is the main source of municipal waste. In the case of waste utilization for economic purposes, proper segregation is important, as it allows directing the separately collected waste to selected recycling processes.

NITROGEN (N)	-	15.7	mg/kg
PHOSPHORUS (P)	-	1.6	mg/kg
POTASSIUM (K)	-	14.8	mg/kg
MAGNESIUM (Mg)	-	1.8	mg/kg
CALCIUM (Ca)	-	13.1	mg/kg
BORON (B)	-	-	mg/kg
COPPER (Cu)	0.173	12.44	mg/kg
MOLYBDENUM (Mo)	0.0123	-	mg/kg
MANGANESE (Mn)	0.73	279.1	mg/kg
ZINC (Zn)	0.905	62.8	mg/kg
IRON (Fe)	-	4.5	mg/kg
NICKEL (Ni)	0.191	5.1	mg/kg
CHROME (Cr)	-	10.4	mg/kg
SELENIUM (Se)	-	-	mg/kg
CADMIUM (Cd)	0.0131	0.27	mg/kg
ARSENIC (As)	0.0027	18.22	mg/kg
LEAD (Pb)	1.65	7.93	mg/kg
MERCURY (Hg)	<0.001	-	mg/kg

Reference:
Riber et al., 2009
Hanc et al., 2011

FOOD WASTE

The main sources of food waste are households. The increase in world population has led to increased food consumption, which has contributed to the increase in the production of food waste. Wasted food is rich in organic matter and nutrients necessary for proper plant growth and development.

NITROGEN (N)	316	291	mg/kg
PHOSPHORUS (P)	552	28.2	mg/kg
POTASSIUM (K)	90	85.9	mg/kg
MAGNESIUM (Mg)	14	-	mg/kg
CALCIUM (Ca)	216	-	mg/kg
BORON (B)	12	-	mg/kg
COPPER (Cu)	31	4.69	mg/kg
MOLYBDENUM (Mo)	-	2.8	mg/kg
MANGANESE (Mn)	60	86.5	mg/kg
ZINC (Zn)	76	22.4	mg/kg
IRON (Fe)	766	111	mg/kg
NICKEL (Ni)	2	2.8	mg/kg
CHROME (Cr)	3	4.21	mg/kg
SELENIUM (Se)	-	0.42	mg/kg
CADMIUM (Cd)	<1	<0.05	mg/kg
ARSENIC (As)	-	-	mg/kg
LEAD (Pb)	4	<0.6	mg/kg
MERCURY (Hg)	-	-	mg/kg

Reference:
Zhang et al., 2007
Valogras et al., 2011

GREEN WASTE COMPOST

grasslands
parks
municipal forests
municipal cemeteries

Green waste is a valuable raw material for the production of compost and is mainly used in this way. Composts that are produced from green waste should show an appropriate degree of ripeness. The possibility of using green waste depends on their selective collection

NITROGEN (N)	374.7	208	mg/kg
PHOSPHORUS (P)	61.1	49	mg/kg
POTASSIUM (K)	245	254	mg/kg
MAGNESIUM (Mg)	30.7	45	mg/kg
CALCIUM (Ca)	186.8	386	mg/kg
BORON (B)	-	-	mg/kg
COPPER (Cu)	32.12	35.15	mg/kg
MOLYBDENUM (Mo)	-	-	mg/kg
MANGANESE (Mn)	-	145	mg/kg
ZINC (Zn)	177	291	mg/kg
IRON (Fe)	-	4,550	mg/kg
NICKEL (Ni)	10.49	6.66	mg/kg
CHROME (Cr)	18.52	13.35	mg/kg
SELENIUM (Se)	-	-	mg/kg
CADMIUM (Cd)	1.41	2	mg/kg
ARSENIC (As)	-	-	mg/kg
LEAD (Pb)	12.8	23.4	mg/kg
MERCURY (Hg)	-	-	mg/kg

Reference:
Halik et al., 2004
Gondek and Filipek-Mazur, 2006

DIGESTATE FROM MUNICIPAL WASTE BIOGAS PLANT

Methane fermentation is a biogas production process that can be produced from organic substrates such as plant biomass. Its chemical composition depends on the substrates used in the biogas plant. Nutrients contained in the digestate in mineral forms are directly available to plants.

NITROGEN (N)	1250	mg/dm3
PHOSPHORUS (P)	14.30	mg/dm3
POTASSIUM (K)	-	mg/dm3
MAGNESIUM (Mg)	-	mg/dm3
CALCIUM (Ca)	-	mg/dm3
BORON (B)	-	mg/dm3
COPPER (Cu)	0.96	mg/dm3
MOLYBDENUM (Mo)	-	mg/dm3
MANGANESE (Mn)	3.9	mg/dm3
ZINC (Zn)	0.63	mg/dm3
IRON (Fe)	2.20	mg/dm3
NICKEL (Ni)	0.27	mg/dm3
CHROME (Cr)	0.24	mg/dm3
SELENIUM (Se)	-	mg/dm3
CADMIUM (Cd)	0.001	mg/dm3
ARSENIC (As)	-	mg/dm3
LEAD (Pb)	0.025	mg/dm3
MERCURY (Hg)	-	mg/dm3

Reference:
Urbanowska and Kotas, 2019

SEWAGE SLUDGE

During the municipal wastewater treatment process sewage sludge is formed, which can be used for fertilizing purposes. The content of the main nutrients varies depending on the composition of the wastewater flowing into the treatment plant and on the place of its formation.

NITROGEN (N)	298	277	mg/kg
PHOSPHORUS (P)	210	356	mg/kg
POTASSIUM (K)	272	25	mg/kg
MAGNESIUM (Mg)	4,420	79	mg/kg
CALCIUM (Ca)	15,800	763	mg/kg
BORON (B)	-	146	mg/kg
COPPER (Cu)	107	438	mg/kg
MOLYBDENUM (Mo)	-	12	mg/kg
MANGANESE (Mn)	-	540	mg/kg
ZINC (Zn)	580	1,607	mg/kg
IRON (Fe)	-	197	mg/kg
NICKEL (Ni)	16.1	960	mg/kg
CHROME (Cr)	28.8	1,592	mg/kg
SELENIUM (Se)	-	<25	mg/kg
CADMIUM (Cd)	1.66	23	mg/kg
ARSENIC (As)	-	150	mg/kg
LEAD (Pb)	20.7	312	mg/kg
MERCURY (Hg)	5.5	2	mg/kg

Reference:
Poluszynska and Slezak, 2015
Tabatabai and Frankenberger, 1979

SEWAGE SLUDGE ASH

As a result of burning sewage sludge, large amounts of ash are formed, which due to the presence of pathogens and heavy metals cannot be used directly on the fields as a fertilizer, however, after proper treatment they are a valuable source of phosphorus, which is necessary for the proper growth and development of plants.

NITROGEN (N)	-	-	mg/kg
PHOSPHORUS (P)	60.7	46,200	mg/kg
POTASSIUM (K)	9,756	10,400	mg/kg
MAGNESIUM (Mg)	13.89	12,700	mg/kg
CALCIUM (Ca)	54.49	80,100	mg/kg
BORON (B)	-	-	mg/kg
COPPER (Cu)	2,260	553	mg/kg
MOLYBDENUM (Mo)	36	-	mg/kg
MANGANESE (Mn)	0.404	-	mg/kg
ZINC (Zn)	3,355	1,990	mg/kg
IRON (Fe)	68.45	131,000	mg/kg
NICKEL (Ni)	290	6,360	mg/kg
CHROME (Cr)	750	159	mg/kg
SELENIUM (Se)	96	-	mg/kg
CADMIUM (Cd)	24	3.8	mg/kg
ARSENIC (As)	38	-	mg/kg
LEAD (Pb)	373	258	mg/kg
MERCURY (Hg)	3	-	mg/kg

Reference:

Lynn et al., 2015
Mattenberger et al., 2008

BIOMASS ASH

One of the most important industrial waste streams in the context of the recovery of biogenic raw materials is biomass ash generated during energy production. Factors affecting the possibility of using biomass ashes as fertilizer are primarily the content of nutrients and the content of toxic heavy metals.

NITROGEN (N)	-	-	mg/kg
PHOSPHORUS (P)	230	-	mg/kg
POTASSIUM (K)	4,400	450	mg/kg
MAGNESIUM (Mg)	380	180	mg/kg
CALCIUM (Ca)	340	1,560	mg/kg
BORON (B)	-	-	mg/kg
COPPER (Cu)	310	342	mg/kg
MOLYBDENUM (Mo)	610	-	mg/kg
MANGANESE (Mn)	960	-	mg/kg
ZINC (Zn)	790	-	mg/kg
IRON (Fe)	-	-	mg/kg
NICKEL (Ni)	980	32.7	mg/kg
CHROME (Cr)	800	49.1	mg/kg
SELENIUM (Se)	200	-	mg/kg
CADMIUM (Cd)	830	10.7	mg/kg
ARSENIC (As)	-	7.42	mg/kg
LEAD (Pb)	380	-	mg/kg
MERCURY (Hg)	-	-	mg/kg

Reference:
Vassilev et al., 2013
Poluszynska and Slezak, 2015

ANIMAL WASTE (MANURE)

Animal waste includes manure and slurry, which have been used as natural fertilizers for years. It is necessary to use this type of waste sustainably for fertilizer purposes, as long-term use can have a negative impact on the soil.

NITROGEN (N)	-	20,900	mg/kg
PHOSPHORUS (P)	-	21.40	mg/kg
POTASSIUM (K)	-	18.70	mg/kg
MAGNESIUM (Mg)	-	4.60	mg/kg
CALCIUM (Ca)	-	23.80	mg/kg
BORON (B)	-	-	mg/kg
COPPER (Cu)	-	411	mg/kg
MOLYBDENUM (Mo)	-	-	mg/kg
MANGANESE (Mn)	-	314	mg/kg
ZINC (Zn)	156	419	mg/kg
IRON (Fe)	-	1.41	mg/kg
NICKEL (Ni)	1.90	22,890	mg/kg
CHROME (Cr)	45.30	29,618	mg/kg
SELENIUM (Se)	-	-	mg/kg
CADMIUM (Cd)	1.80	0.90	mg/kg
ARSENIC (As)	-	-	mg/kg
LEAD (Pb)	12.80	27,791	mg/kg
MERCURY (Hg)	0.12	-	mg/kg

Reference:
Ociepa et al., 2007
Gondek and Filipek-Mazur, 2005

PLANT WASTE COMPOST

Cereal straw and other arable crops are the dominant by-product generated on farms during crop production. One of the possible ways of managing them is the production of fertilizers. This type of waste is composted to improve its chemical and physical properties.

NITROGEN (N)	13.3	mg/kg
PHOSPHORUS (P)	4.70	mg/kg
POTASSIUM (K)	25.40	mg/kg
MAGNESIUM (Mg)	83.25	mg/kg
CALCIUM (Ca)	178.95	mg/kg
BORON (B)	-	mg/kg
COPPER (Cu)	0.52	mg/kg
MOLYBDENUM (Mo)	-	mg/kg
MANGANESE (Mn)	14,366	mg/kg
ZINC (Zn)	22,647	mg/kg
IRON (Fe)	74.63	mg/kg
NICKEL (Ni)	24,259	mg/kg
CHROME (Cr)	13.35	mg/kg
SELENIUM (Se)	-	mg/kg
CADMIUM (Cd)	2	mg/kg
ARSENIC (As)	-	mg/kg
LEAD (Pb)	23.40	mg/kg
MERCURY (Hg)	-	mg/kg

Reference:
Jadia and Fulekar, 2008
Gondek and Filipek-Mazur, 2007

POSITIVE EFFECTS OF USING FERTILISERS FROM WASTE

Stimulation of physicochemical processes that improve the soil's ability to accumulate plant-available components

Increase in microbial activity, resulting in the transition of organic into mineral (available for plants)

Positive effect on chemical processes that act on the increase in the content of micro and macro forms available to plants

Organic waste used in the form of fertilisers, as a result of the action of microfauna and microflora is subjected to processing into minerals and organic matter.

FERTILISERS FROM WASTE

Fertilising the soil with fertilisers made from waste can not only improve the chemical and physical properties of soils but also get rid of onerous waste

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