MIDDLE POMERANIAN SCIENTIFIC SOCIETY OF THE ENVIRONMENT PROTECTION

Rocznik Ochrona Środowiska

Volume 22. Year 2020 ISSN 1506-218X 242-255

Mining, Production and Development of Small Fractions of Gravel and Sand Aggregates in North-Western Poland

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1. Introduction

The gradual deterioration in the quality of raw material base of natural aggregates combined with the simultaneous increase in the demand of the construction industry for the best quality coarse fractions with grain sizes of 5-8, 8-11 mm, etc. (Kozioł & Baic 2018a, Kozioł et al. 2018c, Kozioł & Galos 2013) has a major impact on the growing volume of hard to sell and non-transferable (waste) fractions of aggregates produced in Poland. This applies especially to gravel and sand aggregates since in their resources the share of very fine fractions (below 2 mm) is systematically increasing while the demand for such fractions in construction is limited and they are often treated as useless (waste) material (Domski & Głodkowska 2017, Głodkowska & Laskowska-Bury 2015). Problems with selling fine (waste) sands can be observed, among others, in the north-western region of the country. Since it is practically unknown what the volume of mining, production and consumption of these aggregates is, an attempt was made to assess the quantity of extracted and produced sand fractions of aggregates on a national and regional scale (provinces, regional zones).

2. Resources and mining of gravels and sands in Poland

Gravels and sands belong to the most abundant Polish minerals. The national balance of mineral resources includes over 10,000 documented deposits with total balance resources of approx. 19.470 billion Mg. There are 4,000 developed deposits with economic resources of 3.518 billion Mg. There are over 2.627 active mining plants extracting this type of minerals, and their total economic resources are 2.679 billion Mg (Bilans zasobów…ed. Szuflicki et al. 2008-2019). Domestic sands and gravels extraction in 2018 amounted to 197 million Mg and

since 2015 it has been on an upward trend due to the growing demand caused by the good economic situation in infrastructure (roads) and volumetric construction. The statistical self-sufficiency ratio of economic resources of gravel and sand deposits (including losses) is currently about 15 years, so it is not high given the major problems with obtaining concessions for the exploitation of new deposits. Deposits of gravel and sands are relatively shallow throughout the country and are exploited in all provinces and in the Baltic Sea Area. However, natural conditions are such that they are unevenly distributed. It concerns both the number of deposits, the size of resources, their grain and petrographic composition, their quality, the geological and mining conditions as well as the environmental, social, technical and economic determinants of their exploitation. This situation is, among other things, a consequence of the diverse geological conditions in which crumb sedimentary rock deposits are formed. The most general distinction in the country can be made between two main raw material zones of crumb deposits: the vast zone of the Polish Lowlands and the Carpathian and Sudeten zone (Radwanek-Bąk et al. 2018, Ney 2007). In the first one, covering about 80% of the country's area, there are sediments whose origin is related to the activity of glaciers or glacial waters (the so-called glaciofluvial sediments). The second one is dominated by river accumulation sediments: gravel and sand of river terraces and alluvial fans. In addition, there are also concentrations of crumb minerals on the bottom of the Baltic Sea, although some of them are also of glacial origin. Taking into account more detailed genetic conditions and the resulting regional differentiation of geological and raw material parameters of gravel and sand deposits, three basic occurrence zones are most frequently distinguished (Kozioł et al. 2018, Radwanek-Bąk et al. 2018). The **northern zone** includes the northern part of Polish Lowlands with dry and waterlogged sandy gravel and gravelly sand deposits, containing mainly Scandinavian material – crystalline formations and limestones with an admixture of quartz and sandstones. In the text (Kozioł et al. 2018), this zone includes the following provinces: Zachodniopomorskie, Pomorskie, Warmińsko-Mazurskie, Podlaskie and Lubuskie. The **central zone** includes the southern part of the Polish Lowlands, where partially waterlogged and waterlogged sand and gravel deposits occur, with relatively small resources. This zone is the largest in terms of surface area. It consists of 6 province: Wielkopolskie, Kujawsko-Pomorskie, Mazowieckie, Łódzkie, Świętokrzyskie and Lubelskie. The Carpathian and Sudeten area constitutes the **southern zone** with the predominance of sandy gravel deposits, both fully and partially waterlogged, river accumulation (80-90%) and glaciofluvial accumulation. The following provinces belong to the southern zone: Dolnośląskie, Opolskie, Śląskie, Małopolskie and Podkarpackie.

A serious problem for the production of gravel and sand aggregates in Poland is the deteriorating quality of the grain size of the mineral in the gravel and sand deposits, which has an impact on the production volume of the sought-after gravel assortments and the increase in production costs. The Balance of Mineral Resources and Waters in Poland (Bilans zasobów…ed. Szuflicki et al. 2008-2019), distinguishes three basic subgroups of gravel and sand deposits, differentiated according to the sand point (SP) which determines the percentage share in resources of sand with grain size below 2 mm:

- gravels for which SP is lower than 30%,
- sands with gravel (SP between 30-75%),
- sands – SP > 75%.

The analysis of changes in the volume of resources within the period of 12 years (2007-2018) (Bilans zasobów…ed. Szuflicki et al. 2008-2019), Kozioł et al. 2018b, own calculations) shows that despite the exploitation, we are experiencing quite a large increase in resources, because the total balance resources of gravel and sands in Poland have increased by approx. 29.6% and the economic resources – by 85%; however, it is unfavourable that it is mainly the sand resources (SP > 75) that are growing. The economic resources of sand deposits have doubled (by 198%), while the resources of sand and gravel deposits have increased by almost 50% and the resources of gravel deposits have decreased over 50%. The share of sands in industrial resources has been increasing particularly fast from 25.7 to 45.7%.

3. Resources and mining of gravel and sands in north-western Poland

The following provinces were included in the **north-western** zone of gravel and sand aggregate mining: West Pomeranian and Pomeranian as well as the Baltic Sea Area.

3.1. West Pomeranian Province

In West Pomeranian Province, the balance resources of gravel and sands amount to 1.2 billion Mg, which constitutes about 6.2% of the national resources. These deposits are mainly related to glacial and partially river accumulation. In terms of grain composition, the deposits classified as sand with gravel (SP – 30 to 75%) are predominant, although their share is decreasing. Over 10 years, the share of this group of deposits decreased from 83.7 to 55.0%, and the share of sand deposits increased from 16.3 to 45% (Kozioł, Baic, Stankiewicz 2018c). Industrial resources amount to 347 million Mg, which represents approximately 9.0% of national resources. In terms of the volume of national resources, the West

Pomeranian Province is ranked as the 4th in Poland. In 2018, the extraction of gravels and sands in the West Pomeranian Province totalled 17.15 million Mg and – in comparison with 2017 – it decreased by 1.547 million Mg. 78 deposits were exploited, including 3 deposits producing over 1.0 million Mg (Ginawa, Sępólno Wielkie, Witankowo III) and 7 deposits producing between 0.5 and 1.0 million Mg. Half of the active deposits do not exceed the volume of 40 thousand Mg/year, so their extraction classifies as typical mining for small deposits (up to 2 ha and up to 20 thousand m^3) carried out on the basis of simplified county level permits (concessions). The exploited deposits are mostly sandy gravel (SP 50-75%) or gravelly sand (30-75%) types. The share of sand fractions in the extracted mineral has been increasing – over 12 years (2007-2018), the average sand point value increased from 63.2 to 72.8%. The largest companies involved in the extraction and production of gravel and sand aggregates in the West Pomeranian Province are: Lafarge Kruszywa, Beton Sp. z o.o. and Szczecińskie Kopalnie Surowców Mineralnych, whose total share of extraction in the province exceeds 40%. There are also about 10 companies with the output of 0.5 to 1.0 million Mg.

3.2. Pomeranian Province

In the Pomeranian Province, the balance resources of gravel and sands amount to 1.129 billion Mg, which is about 5.8% of the national resources (Bilans zasobów…ed. Szuflicki et al. 2008-2019). These deposits are mainly related to glacial accumulation. In terms of grain composition, sandy gravel and gravelly sand deposits predominate, but their share in the resources has decreased within 12 years from about 80 to 57%, and the share of sand deposits has increased to 43%. Economic resources have increased in recent years to 343 million Mg. In 2018, 167 deposits were exploited, with the total output of 19.18 million Mg, which increased by 4.15 million Mg, i.e. by 21.68%, compared with 2017. More than 60% of the exploited deposits are very small, with the output of less than 40 thousand Mg/year (county level permits). The output from only 2 deposits exceeded 1 million Mg/year, i.e. the Gliśno and Mirowo deposits. Out of 6 deposits, the extraction output ranged from 0.5 to 1.0 million Mg. The largest aggregate producers are Lafargeholcim Sp. z o.o. and Kruszywa Polskie Sp. z o.o.

3.3. Baltic Sea Area

Currently, within the Baltic Sea Area, 3 deposits of sand and gravel (Słupsk Bank, South Baltic Central Bank, Koszalin Bay) are documented with total resources of 136.3 million Mg of balance resources, 89.94 million Mg of industrial resources and 0.83 million tons of extraction in 2018 (Bilans zasobów…ed. Szuflicki et al. 2008-2019). These deposits are located at depths of 15 to 30 m and their average thickness is 0.9 to 1.0 m (maximum – about 5.0 m). They are located at a distance of 3.0 km (north of Koszalin) up to 90 km

from the borders of the area. These are sand and gravel type deposits with a relatively high share of gravel fraction; sand points of the resources range from 53.7% (South Central Shoal) to 64.0% (Słupsk Shoal) (Kozioł et al. 2011, Kozioł et al. 2017) The South Shoal bed is operated. At the end of 2018, a new, modern dredger by Royal IHC, equipped with an aggregate extraction and processing system, started its operation on this deposit. The vessel – a dredger with the total length of 142 m and a width of 23 m – is equipped with suction heads (mining unit), a set of pumps with a pipeline system, and a processing plant with an aggregate hold. The advantage of the dredger is the possibility to obtain mainly the desired coarse, gravel aggregate fractions by preliminary screening (sieving) of sand fractions. Thanks to this, about 80% of the gravel fractions are obtained from the extracted material, while in the land exploitation the yield of these fractions, depending on the SP, amounts to only 20-30%. The recipients of the produced aggregate are most of the contractors of the Tri-city construction sites, e.g. the tunnel under the Martwa Wisła River, the Pomeranian Metropolitan Railway, the Southern Ring Road of Gdańsk, etc. (Kiewlicz 2019). The production capacity of the dredger is estimated at 2.5 million Mg/year, depending on the customers' demand for aggregate.

4. Change in grain size of gravel and sands on a national scale and in the north-western zone

The parametric quality index (grain size distribution) of documented and exploited gravel and sand resources is defined in geological documentation as the so-called sand point (SP). The assessment of the quantity of fine fractions in the total aggregate and sand resources can be approximated based on the calculation of average sand points in the analysed resources. Assuming the division of documented gravel and sand resources into three basic groups (Bilans zasobów…ed. Szuflicki et al. 2008-2019, Kozioł et al. 2018c), namely sands, sands with gravel and gravel, and determining for each of these groups the average (medium) sand points (SP), i.e. sands – 85%, sands with gravel – 60%, gravel – 25%, the average sand points for the balance, economic and exploited deposits were calculated on the basis of annual balance sheets of minerals. Sample calculations for 2 provinces, 3 zones and the whole country are presented in Table 1 (balance resources), Table 2 (exploited deposits), Figure 1 (balance resources) and Figure 2 (economic resources). The analysis was conducted for the years 2007-2018, which allowed to determine the trend in changes in the content of fine fractions in resources and extracted mineral over a 12-year period.

Table 1. Average sand points in balance resources of gravel and sand aggregate in the years 2007-2018 (Bilans zasobów…ed. Szuflicki et al. 2008-2019, Kozioł et al. 2018c, own calculation)

Description	Average SP in balance resources in years, %											
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Poland	**64.6**	**64.7**	**65.2**	**65.8**	**66.1**	**66.5**	**66.7**	**66.9**	**67.4**	**67.5**	**67.7**	**67.8**
northern zone	62.3	62.6	63.4	63.9	64.3	65.1	65.2	65.5	66.0	66.4	66.7	66.7
central zone	78.4	78.0	78.4	79.0	79.1	79.4	79.5	79.7	79.8	80.0	80.4	80.4
southern zone	58.6	58.8	59.1	59.6	59.9	59.9	60.1	60.2	60.7	60.5	60.3	60.4
Provinces												
Pomeranian	65.1	64.5	65.8	66.5	66.9	67.4	68.3	68.6	69.9	70.7	71.0	71.1
West Pomeranian	64.1	64.4	65.3	66.2	66.0	68.7	68.7	69.9	71.0	71.2	72.0	72.1

Table 1 and Figure 1 show that in 2018 the average sand point in the country in terms of balance resources was 67.8% and it increased by 5% over the period of 12 years. The resources in the southern zone have the lowest SP (60.4%), while in the central region the average SP is the highest and amounts to 80.4%. In the Pomeranian Province, the average SP increased within 12 years from 65.1 to 71.7%, i.e. by 10.9%. An even greater deterioration of aggregate grain size occurred in the West Pomeranian Province, i.e. by 11.2% (SP increased from 64.1 to 72.1%). In the economic resources in Poland in 2018, the average SP was higher in comparison with the balance resources – 70.6%, and – what is characteristic – it increased by as much as 11.5% within the 12-year period; thus, the average annual growth of SP in the economic resources was ca. 1% (Fig. 2). In the Pomeranian Province, the average SP of economic resources increased by as much as 11.4% (up to 74.2%), while a slightly smaller increase was recorded in the West Pomeranian Province by 11.1% (up to 70.9%). From the point of view of exploitation, SP values in the exploited deposits are important (Table 1). In 2018, the average SP in exploited deposits reached 69.3% and increased by 3.9% within the 12-year period. The lowest SP was recorded in the southern zone (62.4% – increase by 4.2%) and the highest in the central zone (80.0%). In the Pomeranian Province, the average SP in the exploited deposits remained at the level of 2007 (69.5%); while in the years 2013-2014, it was at a much lower level – 66.0%. In the West Pomeranian Province, SP increased from 63.2 to 72.8%, or 15.2%.

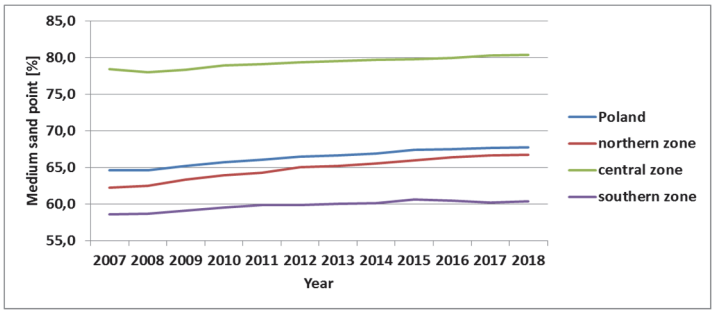

Fig. 1. Trends in the changes in average sand points of for balance resources in the years 2007-2018 (Bilans zasobów…ed. Szuflicki et al. 2008-2019, Kozioł et al. 2018c, own calculation)

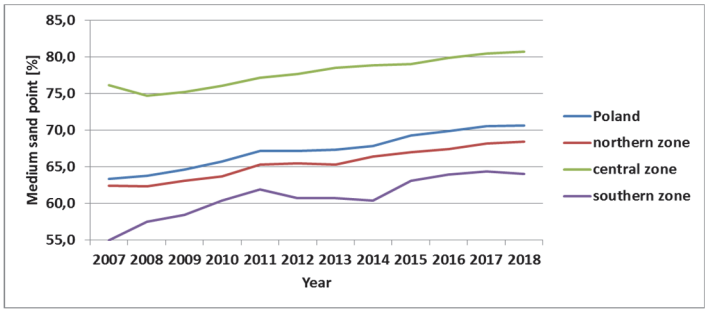

Fig. 2. Trends in the changes in average sand points of economic resources in the years 2007-2018 (Bilans zasobów…ed. Szuflicki et al. 2008-2019, Kozioł et al. 2018c, own calculation)

Table 2. Average sand points in resources extracted of gravel and sand aggregate in the years 2007-2018 (Bilans zasobów…ed. Szuflicki et al. 2008-2019, Kozioł et al. 2018c, own calculation)

Description	Average SP in resources extracted in years, %											
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Poland	66.7	65.9	67.4	68.2	70.1	70.2	70.0	67.5	68.8	69.9	70.1	69.3
northern zone	63.9	63.7	65.2	65.7	66.0	66.1	65.8	64.6	66.0	67.2	67.7	66.9
central zone	75.5	74.5	75.7	76.4	78.6	79.6	79.8	78.4	79.8	79.9	80.3	80.0
southern zone	59.9	59.9	61.5	62.1	64.5	64.5	63.2	61.9	63.2	65.1	63.5	62.4
Provinces												
Pomeranian	70.0	67.2	66.6	68.6	68.2	67.2	66.1	66.0	66.7	70.1	68.5	69.5
West Pomeranian	63.2	64.3	65.7	65.4	65.5	67.0	67.9	66.4	66.2	67.7	74.0	72.8

5. An analysis of the production of sands extracted from exploited deposits

Having estimated the content of sands (0-2 mm) in the extracted mineral, an attempt was made to assess the amount of recovery (production) of this fraction in the extraction and treatment process. In some of the gravel and sand mining technologies applied, part of the fine fractions is already lost in the mining process. In particular, this applies to exploitation under the water surface, which is predominantly used in Poland (approx. 75% of gravel and sand extraction). Actually, only the use of suction dredgers enables the recovery of the majority of fine sand fractions from the extracted mineral, whereas when mining with single-bucket dredges (of grapple, scoop or scraper type) and multi-bucket dredgers (of ladder or chain type), the sand fractions are often melted directly in the post-extraction pit (Witt 2013). In Poland, depending on the mining technology, the demand (which is variable) and region, the recovery (production) of small fractions ranges from 60 to 80% of this fraction's content in the extracted mineral. In the aforementioned work (Kozioł et al. 2018c), the average recovery rate of 70% was assumed for a sample determination of the production volume of fine sand assortments in 2016 (Table 3). In 2016, when 173.2 million Mg of gravel and sand were mined, it was practically possible to obtain approx. 51.8 million Mg of gravel aggregates and 84.6 million Mg of sand assortments (0-2 mm); thus, the estimated total production of gravel and sand aggregates was probably approx. 136.4 million Mg, i.e. approx. 78.7% of the annual production of gravel and sand according to *The Balance of Mineral Resources and Waters in Poland* (Bilans zasobów…ed. Szuflicki et al. 2008-2019, The Balance 2008-2018). The remaining part (21.3%) is made up of losses (useless fractions). Table 3 presents the results of calculations of production (recovery) of fine sand assortments (0-2 mm) in particular regional zones and in the Pomeranian and West Pomeranian Provinces.

Table 3. Production (recovery) sands and gravels in the year 2016 (Kozioł et al. 2018c, own calculation)

Description	Mining in 2016, thousand Mg	SP in resources, %	Fraction's share in the mineral, thousand Mg		Recovery of 0-2 mm fraction, million Mg
			0-2 mm	>2 mm	
Poland	173239	69.9	120764	51825	84.6
northern zone	72039	67.2	48410	23629	33.9
central zone	46596	79.9	37230	9366	26.1
southern zone	53954	65.1	35124	18830	24.6
Provinces					
Pomeranian	17791	70.1	12471	5320	8.7
West Pomeranian	10633	67.7	7199	3434	5.0

In fact, the amount of recovery of small fractions varies, as part of the extracted mineral is used in the form of all-in aggregates (sand and gravel mixture) and sand with the admixture of gravel. The share of these fractions in the production and consumption of aggregates differs depending on the quality and size of resources and the variable demand on the part of the construction industry. A higher share of the consumption of all-in aggregates and sand results mainly from the implementation of road construction engineering works (mainly for road foundation) in some years and provinces. An example of such a period is the years 2011-2012, when approximately 50% of gravel and sand extraction was consumed by road construction in the form of raw sands (Kozioł & Galos 2013); also at present, an increase in demand for these aggregates can be observed.

6. Balance of production and demand for fine assortments of gravel and sand aggregates – an attempt at assessment

Fine assortments of gravel-sand and crushed-stone aggregates are used both in the construction industry as well as outside the construction industry in various branches of economy. Quantitatively, however, the basic demand concerns the construction industry, including primarily the production of concrete and concrete products (prefabricated elements, etc.) (Głodkowska 2018, Naziemiec 2013). The zone division of extraction and production of gravel and sands shows that the positive balance of sand production takes place mainly in the northern region (+19.4 million Mg), while the southern region (+3.2 million Mg) is in balance with the deficit observed in the central region (-3.0 million Mg). Relatively large positive balance of sand production is recorded in two provinces: Pomeranian (+5.3 million Mg) and West Pomeranian (+3.0 million Mg) (see table 4).

Summing up, it can be stated that, for example in 2016, from the production (recovery) balance and forecast consumption of fine sand fractions, almost 20 million Mg of these sands does not find domestic demand and in the majority of cases it is probably transported back to the post-extraction pits. The lack of periodic demand for such sands should be the basis for their classification as a by-product and their storage in separate storage sites.

Between 2017 and 2021 these figures probably are and will be smaller due to the good economic situation in the construction industry, both infrastructural (roads, railways) as well as volumetric, which will result in higher sand consumption, similarly as in the years 2010-2012.

Table 4. Estimation of production and consumption balance of fine gravel and sand aggregate assortments in 2016 (Kozioł et al. 2018c, own calculation)

Description	Extraction in 2016, thousand Mg	Fraction's share in the mineral, thousand Mg		Recovery of 0-2 mm fraction, million Mg	Predicted consumption for concrete	Other consumption	Balance (recovery - consumption)
		0–2 mm	>2 mm		million Mg	million Mg	million Mg
Poland	173239	120764	51825	84.6	29.0	36.0	19.6
northern zone	72039	48410	23629	33.9	6.5	8.0	19.4
central zone	46596	37230	9366	26.1	13.0	16.1	-3.0
southern zone	53954	35124	18830	24.6	9.5	11.9	3.2
Provinces:							
Pomeranian	17791	12471	5320	8.7	1.5	1.9	5.3
West Pomeranian	10633	7199	3434	5.0	0.9	1.1	3.0

7. Final conclusions

1. The above analysis the databases of gravel and sand deposits shows that with the development of documented resources, the share of resources classified as sands increases. A particularly large increase in sand fractions occurs in the industrial resources in the years 2007-2018, i.e. from 25.7% to 45.7%.
2. A measurable indicator of deterioration in resource quality is the trend of changes in the average sand point (SP) of natural aggregates in (percentage fine fraction content 0-2 mm) in documented resources of deposits. In 2018, the average sand point in the documented balance resources was 67.8% and it increased by 5.0% over the period of 12 years (2007-2018). The lowest SP was recorded in resources in the southern region (zone) (60.4%), including two provinces: Małopolskie (50.4%) and Opolskie (58.1%). In the central region, the average SP reaches 80.4%, including 84.2% in the Lubelskie Voivodeship and 83.1% in the Świętokrzyskie Voivodeship.
3. In the economic resources in Poland in 2018, the average SP was higher in comparison with the balance resources, namely 70.6%, and – what is characteristic – it increased by as much as 11.5% during the period of 12 years, i.e. the average annual growth of SP in industrial resources is ca. 1.0%. The highest growth was recorded in the southern region (by 16.4%); thus, the region with the best deposits in terms of quality (grain size) experiences the fastest deterioration.
4. The average PP values in exploited deposits are lower similar in the compared to the value in economic resources (national average 69.3%), which means that deposits with a more favourable granulation are exploited.

5. After the sand content in the extracted mineral was estimated, an attempt was made to assess the amount of recovery (production) of this fraction in the extraction and treatment processes. Estimated calculations show that in 2016, when approximately 173.2 million Mg of gravel and sand were mined, it was actually possible to obtain approximately 51.8 million Mg of gravel aggregates and 84.6 million Mg of sand assortments (0-2 mm); thus, the estimated total production of gravel and sand aggregates probably amounted to approx. 136.4 million Mg, i.e. about 78.7% of the annual production of gravel and sand according. The remaining part (21.3%) represents losses (useless fractions).
6. The zone division of extraction and production of gravel and sands shows that the positive balance of sand production occurs mainly in the northern region (+19.4 million Mg), while the southern region (+3.2 million Mg) is in balance with the deficit in the central region (-3.0 million Mg). Relatively large positive balance of sand production is recorded in two provinces: Pomeranian (+5.3 million Mg) and West Pomeranian (+3.0 million Mg).
7. The volume of fine fractions recovery is changeable because part of the extracted sand and gravel mineral is used in the form of all-in aggregates (sand and gravel mixture) and sand with admixture of gravel. The share of these fractions in the production and consumption of aggregates differs depending on the quality and volume of resources and the alternating demand on the part of the construction industry. A higher share in the consumption of all-in aggregates and sand in some years and provinces results chiefly from the implementation of road infrastructure engineering works (mainly for road foundation). An example of such a period are the years 2011-2012, when approximately 50% of gravel and sand extraction in the form of raw sands was consumed by road construction, and there has also been an increase in demand for sands due to the good economic situation in road infrastructure and volumetric construction.
8. Deterioration of the quality of the raw material base and, at the same time, the increase in the building industry demand for thick aggregate fractions (5/8, 8/11, etc.) contribute to an increase in the extraction of gravel and sand aggregates with a simultaneous increase in the production of fine, hardly marketable assortments of aggregates. The lack of periodic demand for such sands should be the basis for their classification as a by-product and their storage in separate storage sites.
9. In the future, the presented research results should contribute to the development of more accurate market forecasts regarding the demand for and production of natural aggregates in Poland and in individual regions, including especially gravel and sand aggregates.

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Abstract

The gradual deterioration in the quality of raw material base of natural aggregates combined with the simultaneous increase in the demand of the construction industry for the best quality coarse fractions with grain sizes of 5-8 mm, 8-11 mm, etc., has a major impact on the growing volume of hard to sell and non-transferable (waste) fractions of aggregates produced in Poland. This applies especially to gravel and sand aggregates since in their resources the share of very fine fractions (below 2 mm) is systematically increasing, while the demand for such fractions in construction is limited and they are often treated as useless (waste) material. Problems with selling fine (waste) sands can be observed, among others, in the north-western region of the country. Since it is practically unknown what the volume of mining, production and consumption of these aggregates is, an attempt was made to assess the quantity of extracted and produced sand fractions of aggregates on a national and regional scale (provinces, regional zones). What constitutes a measurable indicator of the deterioration in the quality of resources is the tendency towards change in the average sand point (the percentage content of fine fraction of 0-2 mm) in the documented resources. For example in 2018, the average sand point in the balance resources was 67.8% and it increased by 5% over the period of 12 years (2007-2018). In the economic resources in Poland in 2018, the average SP was higher in comparison with the balance resources, namely 70.6%, and – what is characteristic – it increased by as much as 11.5% during the period of 12 years, i.e. the average annual growth of SP in industrial resources is ca. 1.0%. The highest growth was recorded in the southern region (by 16.4%); thus, the region with the best deposits in terms of quality (grain size) experiences the fastest deterioration. Estimated calculations show that in 2016, it was actually possible to obtain approximately 51.8 million Mg of gravel aggregates and 84.6 million Mg of sand assortments (0-2 mm); thus, the estimated total production of gravel and sand aggregates probably amounted to approx. 136.4 million Mg, i.e. about 78.7% of the annual production of gravel and sand according to PGI. The remaining part (21.3%) represents losses (useless fractions). The zone division of extraction and production of gravel and sands shows that the positive balance of sand production occurs mainly in the northern region (+19.4 million Mg), while the southern region (+3.2 million Mg) is in balance with the deficit in the central region (-3.0 million Mg). Relatively large positive balance of sand production is recorded in two provinces: Pomeranian (+5.3 million Mg) and West Pomeranian (+3.0 million Mg). The lack of periodic demand for such sands should be the basis for their classification as a by-product and their storage in separate storage sites. The analysis and calculations should contribute to the development of more accurate market forecasts of demand for and production of natural aggregates, especially of gravel and sand, both in Poland and in individual regions.

Keywords:
rock raw minerals, gravel and sand aggregates, gravel and sand extraction

Wydobycie, produkcja i zagospodarowanie drobnych frakcji kruszyw żwirowo-piaskowych w Polsce północno-zachodniej

Streszczenie

Stopniowe pogarszanie się jakości bazy surowcowej kruszyw naturalnych i równocześnie wzrost zapotrzebowania budownictwa na najlepsze jakościowo grube frakcje o uziarnieniu 5-8 mm, 8-11 mm, itd., ma duży wpływ na wzrost frakcji trudno zbywalnych i niezbywalnych (odpadowych) produkowanych w kraju kruszyw. Dotyczy to szczególnie kruszyw żwirowo-piaskowych w zasobach których systematycznie wzrasta udział frakcji drobnych (poniżej 2 mm), na które jest ograniczone zapotrzebowanie budownictwa i często traktowane są jako materiał nieużyteczny (odpadowy). Problemy ze zbyciem drobnych (odpadowych) piasków występują miedzy innymi w regionie północno-zachodnim kraju. Ponieważ praktycznie nie wiadomo jakie jest wydobycie, produkcja i zużycie tych kruszyw podjęto próbę oceny w skali kraju i poszczególnych regionów (województw, stref regionalnych) ilości wydobywanych i produkowanych frakcji piaskowych kruszyw. Wymiernym wskaźnikiem pogarszania się jakości zasobów kruszyw jest tendencja zmian średniego punktu piaskowego (procentowa zawartość frakcji drobnej 0-2 mm) w udokumentowanych zasobach. Przykładowo w 2018 r. w zasobach bilansowych średni punkt piaskowy wyniósł 67,8% i w ciągu 12 lat (2007-2018) wzrósł o 5%. W zasobach przemysłowych w kraju w 2018 r. średni PP był wyższy w porównaniu do zasobów bilansowych – 70,6% i co charakterystyczne w ciągu 12 lat wzrósł aż o 11,5%, czyli średnioroczny wzrost PP w zasobach przemysłowych wynosi ok. 1%. Najwyższy wzrost odnotowano w regionie południowym (o 16,4%), czyli w regionie mającym pod względem jakości (uziarnienia) najlepsze złoża, następuje najszybsze ich pogorszenie. Z przeprowadzonych szacunkowych obliczeń wynika, że w 2016 roku praktycznie możliwe było do uzyskania ok. 51,8 mln Mg kruszyw żwirowych i 84,6 mln Mg asortymentów piaskowych (0-2 mm), czyli szacowana łączna produkcja kruszyw żwirowo-piaskowych prawdopodobnie wyniosła ok. 136,4 mln Mg to jest ok.78,7% rocznego wydobycia wg PIG żwirów i piasków. Pozostałą część (21,3%) stanowiły straty (frakcje nie użyteczne). Z podziału strefowego wydobycia i produkcji żwirów i piasków wynika, że dodatnie saldo produkcji piasków ma głownie region północny (+19,4 mln Mg), zaś region południowy (+3,2 mln Mg) bilansuje się z deficytowym regionem środkowym (-3,0 mln Mg). Stosunkowo duże saldo dodatnie produkcji piasków mają województwa pomorskie (+5,3 mln Mg) i zachodniopomorskie (+3,0 mln Mg). Brak okresowego zapotrzebowania na tego typu piaski powinien być podstawą do ich uznania jako produkt uboczny i ich składowania na oddzielnych składowiskach. Analiza i obliczenia powinny się przyczynić do opracowania dokładniejszych prognoz rynkowych zapotrzebowania i produkcji w Polsce i w poszczególnych regionach kruszyw naturalnych w tym szczególnie kruszyw żwirowo-piaskowych.

Słowa kluczowe:
surowce skalne, kruszywa żwirowo-piaskowe, wydobycie żwirów i piasków