Title: Influence of atmospheric pollution on acceleration of overgroving process in Błędów "Desert"

Author: Oimahmad Rahmonov, Małgorzata Rahmonov, Sergiusz Szczypek

Citation style: Rahmonov Oimahmad, Rahmonov Małgorzata, Szczypek Sergiusz. (2007). Influence of atmospheric pollution on acceleration of overgroving process in Błędów "Desert". "Acta Geographica Silesiana" ([T.] 2 (2007), s. 41-46).

Oimahmad Rahmonov[1], Małgorzata Rahmonov[2], Sergiusz Szczypek[2]

[1]*University of Silesia, Faculty of Earth Sciences, Będzińska str. 60, 41-200 Sosnowiec, Poland*
[2]*Ecological High School, Partyzantów str. 11, 41-200 Sosnowiec, Poland*

INFLUENCE OF ATMOSPHERIC POLLUTION ON ACCELERATION OF OVERGROVING PROCESS IN BŁĘDÓW "DESERT"

Rahmonov J., Rahmonov M., Szczypek S. **Wpływ zanieczyszczeń powietrza atmosferycznego na przyspieszenie procesu zarastania Pustyni Błędowskiej**. Od połowy lat 1970. obszar Pustyni Błędowskiej, położonej w południowej Polsce (rys. 1), intensywnie zarasta. Ma to związek zarówno ze świadomym wprowadzaniem specjalnych gatunków w celu utrwalenia ruchomego piaszczystego podłoża, jak i z naturalną sukcesją roślinności. Głównym celem artykułu jest próba odpowiedzi na pytanie, w jakim stopniu tę sukcesję przyspieszyły zanieczyszczenia atmosfery (pył, SO_2 i NO_x) w latach 1970. i 1980. Stwierdzono, że zanieczyszczenia te były duże i bardzo duże (rys. 2–4). Na podstawie ich analizy oraz na podstawie danych literaturowych można wnioskować, że ówczesny stan zanieczyszczeń powietrza jest w znacznym stopniu odpowiedzialny za zarastanie tego obszaru.

Рахмонов О., Рахмонов М., Щипек С. **Влияние загрязнений атмосферного воздуха на ускорение процесса зарастания територии Блендовской „пустыни"**. С середины 1970-х гг. террирория Блендовской „пустыни", расположенной в Южной Польше (рис. 1), интенсивно зарастает. Это связано как с целенаправленным насаждением специальных видов для закрепления подвижного песчаного субстрата, так и с естественной сукцессией растительности. Цель настоящей статьи – попытка установить, в какой степени данную сукцессию ускорили загрязнения атмосферного воздуха (пыль, SO_2 и NO_x) в 1970-х и 1980-х гг. Выявлено, что загрязнения отличались высоким и очень высоким уровнем (рис. 2–4). На основании анализа загрязнений, а также анализа литературных истчников можно сделать вывод, что тогдашнее состояние загрязнений атмосферы в значительной степени повлияло на процесс зарастания Блендовской „пустыни".

Abstract

Since the half of 1970. the area of Błędów "Desert", which is located in the south part of Poland (fig. 1), has undergone the process of intensive overgrowing. It is connected with conscious introduction of plant species in order to stabilise loose sand as well as also with natural succession. The main aim of this article is to answer to question in which degree atmospheric pollution (dust, SO_2 and NO_x) accelerated the rate of succession, especially in 1970. & 1980. Therefore, in the degree of pollution was analysed (fig. 2–4) and it was stated, that atmospheric deposition of pollutants was high and very high. On the basis of analysis and literature data it is possible to state that atmospheric pollution is of significant responsibility for overgrowing of this area.

INTRODUCTION

As far back as in the years 1960s. the Błędów "Desert" (fig. 1) was almost completely devoid of vegetation, what made of its large, although completely not used landscape attractiveness. Since the years 1970s., and especially since the latter half of this decade, the decided acceleration of ve-

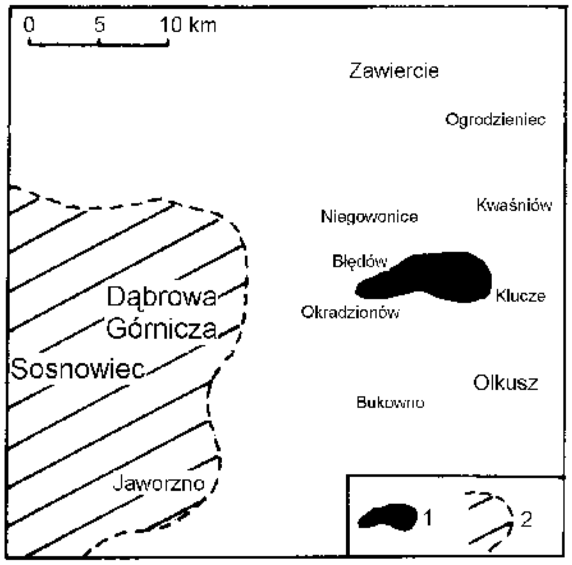

Fig. 1. Location of Błędów "Desert" (1) in relation to Upper Silesian Industrial Region (2)
Rys. 1. Położenie Pustyni Błędowskiej (1) w stosunku do Górnośląskiego Okręgu Przemysłowego (2)

getation succession in this area followed. There are opinions that this process could have connection with intensive ambient concentration of different air pollutants.

This paper focuses on the explaining of the influence of atmospheric fertilising in a form of dry and wet falls on the fertilising of sands in Błędów "Desert" and the rate of this area overgrowing. In connection with it the analysis of dust fall and concentrations of SO_2 and NO_x was carried out in the last 25 years on the base of published materials taken from the Provincial Sanitary-Epidemiological Station in Katowice and Silesian Provincial Sanitary-Epidemiological Station in Katowice.

IMPORTANCE OF DUST FALL AND CONCENTRATIONS OF NITROGEN AND SULPHUR IN THE AIR FOR THE DEVELOPMENT OF VEGETATION

Owing to anthropogenic activity in the last years the deposition of dry and wet falls of nitrogen and sulphur in different land ecosystems clearly increased, what caused the disturbances of biochemical cycle of these elements (Singh, Tripathi, 2000). Owing to carrying by winds of gaseous, fine-dropped and dusty industrial emission into different distances they can get into ecosystems and cause changes in them (Prusinkienwicz, Pokojska, 1989; Berendse, Aerts, Bobbink, 1993; Pokojska, Kwiatkowska, Szrejder, 1999). Along the way they transform into new compounds, which in the further order fall and reach the soil, water or depose at the plant surface. The source of these pollutants is most often fossil fuel burning and industrial processes. As opposed to SO_2, which origins from the sul-phur included in the fuel, NO_x are mostly created in the process of burning owing to reaction of nitrogen and oxygen included in the air taken up during burning (Meixner, 1994). It is conside-red that pollution by nitrogen oxides in Europe still increases, mainly due to the increase in num-ber of vehicles (Matson, Lohse, Hall, 2002). Other important sources of nitrogen compounds in the air are artificial and natural animal fertilisers from arable lands, from which ammonium is raised into the air. Therefore the soil can be richly ferti-lised from the air. It was stated that e.g. falls of atmospheric nitrogen, fertilising land ecosystems in Holland, origin from ammonium changing in areas with intensive agriculture (e.g. dairies and cattle breeding). The consequence of large supply of nitrogen from the atmosphere into sandy ecosy-stems, which are poor in nutrients in Holland, is the occurrence of exceptionally quickly succes-sion, causing undesirable changes in their species composition (Berendse, Aerts, Bobbink, 1993). Fall, which is rich in nitrogen, is an important nutrient element for soil formed and microorga-nisms. Nitrogen accumulation in ecosystems is probably one of main forces making succession, which determines its rate and the dynamics of spe-cies composition (Crocker, Major, 1995; Be-rendse, 1990). The majority of species is adap-ted to life at nitrogen deficiency, and now they obtain it in the excess. This problem was obser-ved e.g. in Sweden (Binkley, Högberg, 1997).

Industrial emission acidifying influences on the soil, what is mainly connected with the activity of SO_2, H_2SO_4 and NO_x and HNO_3. These acids, together with acids produced in ecosystem processes cause the reaction chain, which can cause energetic weathering of soil minerals liable to decomposition and leaching of soluble products beyond the range of plant roots, and accelerated mineral weathering can temporarily cause positive effects through plant supply with easily available nutrients (Prusinkiewicz, Pokoj-ska, 1989; Juda-Rezler, 2000).

The following element having the influence on the ecosystems fertilising is fall of dusts. Alkaline substances included in dusts emitted from cement, lime and magnesite plants and in gases also play the essential role in ecosystems (Jabłonska, 2000). Weakly alkaline dusts can be also introduced into the atmosphere by power industry (e.g. ash after coal burning) and metallurgy. The presence of certain amounts of neutralising dusts in the air over industrialised areas causes that there acid rains do not occur despite of high level of SO_2 emission (Greszta, 1975; Strzyszcz, 1982). In dusts from cement plants in different proportions calcium and potassium oxides are included. These elements not only decrease the acidity in soil, but they also make the nutrient.

Neutralisation of acidity by falls containing calcium causes the increase in biological activity of soil in the form of quick decomposition of soil organic matter and introducing of nutrient substance into biological cycle, because it is temporarily trapped in it. In the same time the assimilability of other cations displaced from sorption complex by calcium ions into soil solution increases (Prusinkiewicz, Pokojska, 1989).

AIR POLLUTION IN THE AREA OF BŁĘDÓW "DESERT" IN THE LAST 25 YEARS OF THE 20TH CENTURY

Analyses of air pollution were made in relation to localities which directly adjoin the Błędów "Desert" (Błędów, Klucze) and which are located in relatively small distance from this area (Bukowno, Bolesław, Niegowonice, Okradzionów, Kwaśniów, Ogrodzieniec) in randomly selected four time limits: years 1978, 1985, 1995 and 2000, which – as it seems – reflect economical situation as well as the increase in interest in the environmental protection. As it was signalised in the introduction – concentrations of NO_x and SO_2 as well as dust falls were analysed.

At the beginning of research period the **concentrations of nitrogen oxides (NO_x)** in the air above the Błędów Desert were about 190 μg/m^3, but in its western part they were slightly higher than in the eastern one. In the following periods these concentrations gradually decreased (up to about 85 μg/m^3 in 1985 and about 65 μg/m^3 – in 1995). Therefore in this period they were from about 1,5 up to almost 5 times higher than it is assumed in (actual) standard 40 μg/m^3. Not until in the year 2000 these pollutions dropped to the value below the reference level (fig. 2).

The distribution of concentrations of NO_x over the Błędów Desert is in accordance with the direction of prevailing here western and south-western winds. The main emitter of these pollutants in Poland is industry (including power) and transport (Juda-Rezler, 2000 and others), therefore such distribution clearly suggests the influence of the Upper Silesian Industrial Region, and because in the last years the economy restructuring in U.S.I.R. follows, therefore this compound concentration in the area discusses decreased.

Concentrations of SO_2 over the area of Błędów "Desert" at the end of the 1970s. years on average reached values 60–65 μg/m^3 (fig. 3). It was similar to the mid of the 1980s. years. Not until in the last decade the level of this pollutant dropped up to 45–50 μg/m^3. Therefore in this period concentrations of SO_2 in the area discussed also exceeded the permissible standards (30 μg/m^3) from 1,5 up to slightly more than 2 times. Similarly as in the case of nitrogen oxides not until in the 2000 year values of pollution by sulphur dioxide decreased below the permissible standard. The main source of SO_2 in the air is fuel burning; therefore again it is possible to say that the main „supplier" of this pollutant over the Błędów "Desert" is the U.S.I.R., the metallurgical plants in Bukowno and Zawiercie as well as power plant in Jaworzno.

Dust fall in the area of Błędów "Desert" during the whole analysed period was located even within the range of presently legally binding standard (200 t/km^2/rok): at the end of the 1970s. it amounted to from about 120 up to about 190 t/km^2/year, and in the mid 1980s. – from 120 to 160 t/km^2/year, whereas in the mid of the 1990s. – from about 50 up to about 70–75 t/km^2/year. Only at the end of the 20th century this value decreased below 30 t/km^2/year (fig. 4).

Dusts falling into Błędów "Desert" also origins from the area of U.S.I.R., from Zawiercie and Ogrodzieniec (cement plant), Bukowno and Jaworzno.

DISCUSSION

Due to common in soil deficit of available nitrogen forms, the first reaction of ecosystem to the supply of this element through atmospheric falls can be positive, especially in initial stages of soil and vegetation development at poor sandy habitats.

In result of atmospheric nitrogen deposition in the majority of moors in Holland, predominating: heather *Calluna vulgaris* and heath *Erica tetralix* were replaced by *Molinia caerulea, Deschampsia flexuosa* and *Festuca ovina* (Berendse, Aerts, Bobbink, 1993). In the area of Błę-dów "Desert" in terrain depressions and – rarely – at flat sandy surfaces single clumps *Molinia caerulea* are also observed, what suggests that their occurrence can have connection with nitric fertilising of terrain surface.

Experimental simulations with fertilising by nitrogen caused the invasion of *Brachypodium pin-natum* at moors and association *Violo-Corynepho-retum dunense* (Ketner-Oostra, van der Loo, 1998). Deposition of atmospheric nitrogen incre-ases the development of bushes and trees, when other nutrients were not limited (Singh, Tripa-thi, 2000). Supply of nutrients from the atmo-sphere into ecosystems can cause the disturbance of ecological homeostasis or can improve the food status of habitats in other ecosystems. It can have the long-lasting influence on biogeocenosis proper-ties (Singh, Tripathi, 2000): nitrogen deposition causes the soil acidification, the change in food re-lations, and mycorrhiza symbiosis within plant spe-cies decreases. Nonetheless, nitrogen deposition can cause the qualitative change in plant tissue and increase in the level of components in the soil. The rate of decomposition of plant litter under the influence of nitrogen and sulphur deposition (especially in the form of acids) increases, what in turn significantly influences the chemical properties of the soil. Such way of activity of nitrogen compo-

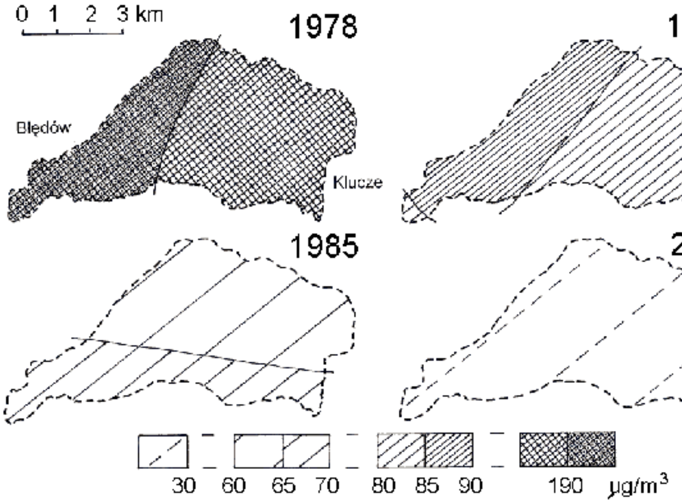

Fig. .2. Concentration of NO_x in air over Błędów "Desert" (μ/m^3) in the last quarter of the 20th century
Rys. 2. Stężenie NO_x w powietrzu nad Pustynią Błędowską (μ/m^3) w ostatnim ćwierćwieczu XX wieku

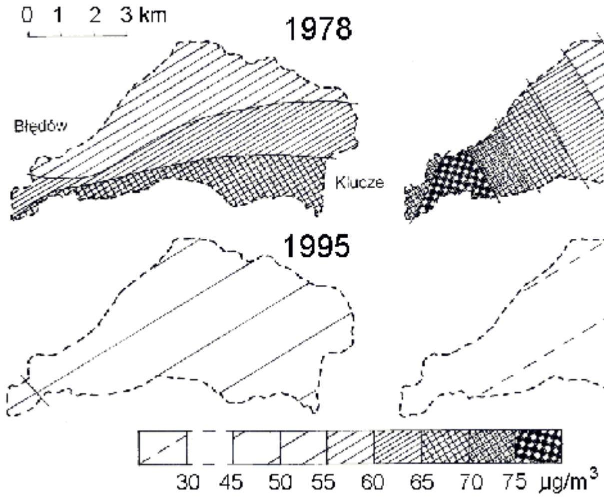

Fig. .2. Concentration of SO_2 in air over Błędów "Desert" (μ/m^3) in the last quarter of the 20th century
Rys. 2. Stężenie SO_2 w powietrzu nad Pustynią Błędowską (μ/m^3) w ostatnim ćwierćwieczu XX wieku

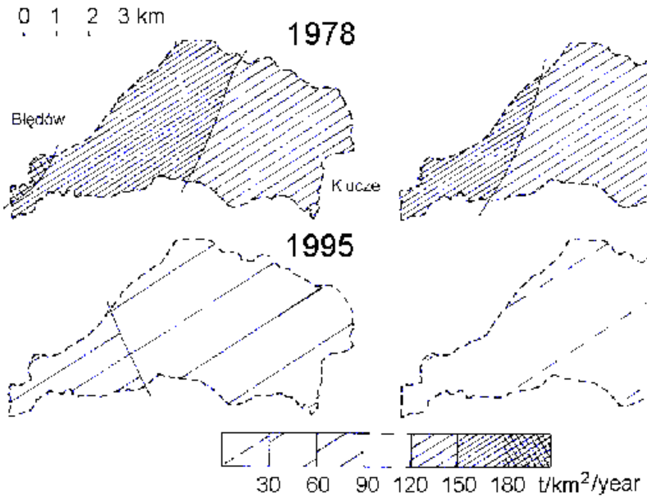

Fig. 4. Dust deposition (in tones/km^2/year) into the area of Błędów "Desert" in the last quarter of the 20th century
Rys. 4. Opad pyłu (w t/km^2/rok) na obszar Pustyni Błędowskiej w ostatnim ćwierćwieczu XX wieku

unds undoubtedly could accelerate disappearance or decrease in the area of bare sands in Błędów "Desert".

In the mid of the 1980s. years, during carried out monitoring at inshore dunes in Holland, the quick changes in vegetation were observed which consisted in increasing in area connected with bryophytes and psammophylous grasses. These relatively quick changes are attributed to acid rains and nitrogen deposition (Heil, van der Meulen, Ten Harkel, 1990). From other investigations (Ketner-Oostra, van der Loo, 1998) results, that within grass species only bryophytes in the best way used from nitrogen compounds, originating from atmospheric deposition, which result was the accelerated succession in poor dune sands. The clear influence of atmospheric nitrogen deposition on the acceleration of succession rate in the association *Violo-Corynephoretum dunense* was also stated at inshore dunes in Holland. On the Błędów "Desert" *Polytrichum piliferum* also shows the large vitality at large surfaces (Rahmonow, 1999: Rahmonov, 2007), what can be also conditio-ned by similar phenomenon as in Holland. One should emphasize, that one of main reasons of disappearance of grass on sands in Europe is con-sidered to be the destruction of habitat, occurring through expansion of urban areas and the chan-ge in the way of land use, deposition of atmo-spheric nitrogen and other factors (Quinger, Me-yer, 1995; Ssymank et al., 1998).

FINAL REMARKS AND CONCLUSIONS

Considering the low resources of humus at initial soils of area investigated, the majority of substances reaching from the atmosphere into the ground surface – in respect of large sand permeability – is easily washed towards the depth of soil profile. But it seems, that the surface of sand covered by algae felt and bryophytes retains more and more falls than the surface with grassy vegetation. It is connected with crusty (lack of canopy) character of communities of cryptogamous plants (falling into sand surface of alkaline dusts and nitrogen compounds could favour the creation of biological soil crust, which is responsible for the stabilisation of hitherto mobile sands and indirectly for succession acceleration), where falls can reach the whole community in the same amounts, on contrary to communities of varied canopy size. In such areas the succession rate is higher.

In the area investigated atmospheric precipitation of slightly alkaline character occurs: the content of Ca^{2+} fluctuates in them per year within the range of 7–11 mg/l, SO^{2-} – 18–39 mg/l, NO_3^- – 9–12 mg/l, Cl^- – 7–11 mg/l (Leśniok, 1996). In dusts of cement plant in Ogrodzieniec (and certainly also power plants) calcium and potassium oxides are included in different proportions. These elements not only decrease the acidity in the soil but they also make the nutrient. In the Błędów "Desert" larger – in relation to other alkaline cations (Mg, K, Na) – contents of Ca are observed in the soil sorption complex in their upper horizons, what partly can result from dry and wet deposition (authors unpublished materials).

Therefore taking into account: 1) the fact that the area of Błędów Desert was characterised by very recently large or significant pollution by nitrogen, sulphur compounds and dust and 2) facts quoted from other sandy areas of Europe, especially Holland, it is possible to assume, that in succession acceleration on sands of the Błędów "Desert" dust, nitrogen and sulphur falls played probably very essential role.

REFERENCES

Berendse F., 1990: Organic matter accumulation and nitrogen mineralization during secondary succession in heath-land ecosystems. Journal of Ecology, 39: 136–138.

Berendse F., Aerts R., Bobbink R., 1993: Atmospheric nitrogen deposition and its impact on terrestrial ecosystems. In: Claire C., Opdam P. (eds.): Landscape Ecology of a Stressed Environment. Chapman and Hall, London: 104–120.

Binkley D., Högberg P., 1997: Does atmospheric deposition of nitrogen threaten Swedish forest? Forest Ecology and Management, 92: 119–152.

Crocker R. L., Major J., 1995: Soil development in relation to vegetation and surface age at Glacier Bay, Alaska. Journal of Ecology, 43: 427–448.

Greszta J., 1975: Wpływ imisji na siedlisko borowe i drzewostany sosnowe w Śląsko-Krakowskim Okręgu Przemysłowym. PWN, Warszawa: 182 s.

Heil C. W, Van der Meulen F., Ten Harkel M. J., 1990: Invloed van atmosferische depositie op de ontwikkeling van droge duingrasland vegetaties. K.N.A.G. Geogr. Tijdschr., 24: 427–432.

Jabłonska M., 2000: Main components of atmospheric dust particles, their influence on natural environment. In: Mineralogical factors in bioecology – proceedings material from 5–8.VI in Syktyvkar, Republic of Komi, Russia. Russian Academy of Sciences, Ural Branch, Komi Scientific Center, Russian Mineralogical Society: 188–190.

Juda-Rezler K., 2000: Oddziaływanie zanieczyszczeń powietrza na środowisko. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa: 243 s.

Ketner-Oostra R., van der Loo H., 1998: Is lichen-rich dry dune grassland (*Violo-Corynephoretum dunense*) on the verge of disappearing from the West-Frisian Islands, through aerial eutrophication? Senckenbergina Maritima, 29, 1/6: 45–49.

Leśniok M., 1996: Zanieczyszczenie wód opadowych w obrębie Wyżyny Śląsko-Krakowskiej. UŚ, Katowice: 124 ss.

Matson P., Lohse K. A, Hall S.J., 2002: The globalization of nitrogen deposition: consequences for terrestial ecosystems. Ambio, 31, 2: 113–119.

Meixner F. X., 1994: Surface exchange of odd nitrogen oxides. Nova Acta Leopoldina, 70, 288: 299–348.

Pokojska U., Kwiatkowska A., Szrejder B., 1999: Wpływ imisji związków siarki z toruńskich zakładów przemysłu nieorganicznego „Polchem" na okoliczne gleby rdzawe. Zeszyty Naukowe, 217 – Rolnictwo, 43: 97–106

Prusinkienwicz Z., Pokojska U., 1989: Wpływ imisji przemysłowych na gleby i życie drzew w środowisku skażonym. Nasze drzewa leśne, 21. PWN, Poznań: 223–244.

Quinger B., Meyer N., 1995: Lebensraumtyp Sandrasen. Landschafts-Pflegekonzept Bayern II. 4 (Hrsg.). Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (StMLU) und Bayerische Akademie für Naturschutz und Landschaftspflege (ANL). München: 253 pp.

Rahmonow O., 1999: Procesy zarastania Pustyni Błędowskiej. WNoZ UŚ, Sosnowiec: 72 s.

Rahmonov O., 2007: Relacje między roślinnością i glebą w inicjalnej fazie sukcesji na obszarach piaszczystych. UŚ, Katowice: 198 s.

Singh K. P, Tripathi S. K., 2000: Impact of enviromental nutrient loading on the structure and functioning of terrestrial ecosystems. Current Science, 79, 3: 316–323.

Ssymank A., Hauke U., Rückriem S., Schröder E., 1998: Das europäische Schutz-gebietssystem NATURA 2000. Schr.-R. f. Landschaftspfl. u. Natursch., 53: 558 pp.

Strzyszcz Z, 1982: Oddziaływania przemysłu na środowisko glebowe i możliwości jego rekultywacji. PWN, Zakład Naukowy im. Ossolińskich: 92 s.