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The assessment of environmental risk on the areas degraded by the landfills

Key words

Neutralization of wastes, landfills, impact of landfills, mathematical models, environmental risk assessment

Abstract

The amount of knowledge and tools to make the environmental risk assessment of old landfills and polluted industrial areas has already been very large. The tools of such activities applied in the United States and Great Britain can be found on the internet websites www.nap.edu and some publications on the website of the U.S. Environmental Protection Agency (www.epa.gov) are available free of charge. The selection of the applied algorithms, parameters and scale of grades depends on the available data or the possibilities of obtaining them, which is practically impossible for most landfills in Poland. To estimate the risk and classify the objects requiring repairing measures, a mathematical formula has been created for Poland.

To define the nuisance made by landfills for the environment two parameters were introduced:

— parameter of waste accumulation U_N, defined as the ratio of the synthetic environmental risk index (R) to the amount of deposited wastes,

— parameter of the neutralization of wastes U_U, defined as the ratio of the synthetic environmental risk index (R) to the number of residents sending wastes to the landfill.

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Introduction

Just before Polish admittance to the European Union it became necessary for Poland to adjust waste management to the requirements of the European Union. The negotiations in the area of "Environment" were preliminarily finished at the Accession Conference on October 26, 2001. At this Conference the European Union accepted 9 requests for transition periods and within the topic of wastes — three legal acts:

- Directive 94/62/EC on packages and package-related wastes, 5-years transition period (until December 31, 2007),
- Directive 99/31/EC on landfills, 10-years transition period (until July 1, 2012),
- Enactment 259/93/EEC on the supervision and control of waste transport within and to the European Union and beyond its territory, 5-years transition period (until December 31, 2007).

A necessary condition for the introduction of changes in the functioning of landfills and their adjustment to the European Union standards is collecting full data on all the existing in Poland landfills of both industrial, as well as municipal wastes. Based on that, one can take repairing measures concerning the landfill or make a decision to close the object if its modernization is not justified for economical or environmental reasons.

It became necessary to collect comprehensive information on Polish landfills and to assess their impact on environment, in order to allow administrative actions to adjust the landfills to new legal regulations. The tool enabling to obtain detail data are environmental audits, compulsory for each landfill to be completed until June 30, 2002.

The purpose of environmental audits in landfills was explained in paragraph 2 art. 33 of *the introduction law* (Grzesik-Filus, Kozakiewicz, Mikołajczak 2003) where it was stated that *if the environmental audit implies the need for the adjustment of the landfill to the Law on Wastes, the manager of the landfill can be obliged to apply for the permission to change the way of the use of the construction or its part or the permission to build a landfill by the reconstruction of the object.* It has been stated in the law that this should take place not later than December 31, 2009.

Generally the authorities of districts (powiat) have not applied art. 33 par. 2 of *the introduction law*. They have not ordered to apply for the permission to change the way of the use of the construction or its part or the permission to build a landfill by the reconstruction of the object. One should emphasize that environmental audits, despite considerable financial costs to make them, have not resulted in proper repairing measures, even in case of landfills that should be closed immediately due to environmental hazard.

According to the Main Office for the Statistics — GUS (Ochrona środowiska 2002 — Główny Urząd Statystyczny) within the borders of the Małopolska Province (Voivodship) there are 47 functioning landfills for municipal wastes of a total surface of 100.2 ha, while the Provincial Plan of Waste Management (http://www.malopolskie.pl) gives the number of 60 landfills. The landfills of municipal wastes in Małopolska do not differ from the ones in other parts of Poland in terms of the localization, construction, exploitation, environmental impact,

safety measures, ways of liquidation etc. The data of the Provincial Inspector for Environmental Protection (WIOŚ) in Cracow (Kraków) indicate that out of 60 landfills of municipal wastes as much as 29 do not have any sealing, majority do not have regulated legal status, only 17 have a compactor, on one landfill biogas is used, on few of them full monitoring of underground waters, surface waters, effluents and landfill gas is carried out, on 20 landfills no documentation of wastes is carried out and 6 landfills are to be closed. Generally, most objects do not fulfil the EU standards (Directive 1999/31/EC) and Polish requirements (Law on Wastes). Since December 23, 2002 the Enactment of the Minister of Environment on the scope, time, manner and the conditions of the monitoring of landfills has been compulsory. This enactment is very rigorous and is based on the annexes of the Council Directive 1999/31/EC of April 26, 1999 on landfills. For the existing landfills of municipal wastes a monitoring is required both on the stage of exploitation as well as over the period of 30 years after the exploitation is finished.

Full determination of index parameters and complete investigation of surface and underground waters, effluents, landfill gas, as required in the Enactment will be very expensive. Lots of small municipalities (communes) managing landfills of municipal wastes will not be able to pay for this. One should expect that small municipal landfills of about 1—2 ha (common in Małopolska) will be gradually closed and inter-municipal unions will build landfills meeting the requirements of the European Union standards, instead.

It would be very useful to make a list of the landfills, taking as a criterion the nuisance they make to the environment. Making such a ranking is however not possible, because there is no objective method to assess the landfills' impact on the elements of environment.

In June 2003 an outline of the new Directive on wastes in mining industry was made. The project of the Directive of the European Parliament and European Council referring to the management of wastes from mining industry (CPM(2003)319-C5-0256/2003-2003/0107 (COD)), does not significantly change the Polish regulations on wastes, but requires the classification of landfills in terms of the nuisance they inflict to the environment.

1. Methods applied over the world

The knowledge and tools to make the environmental risk assessment of old landfills and polluted industrial areas has already been very large. The tools of such activities applied in the United States and Great Britain can be found on the internet websites www.nap.edu and some publications on the website of the U.S. Environmental Protection Agency (www.epa.gov) are available free of charge.

The problem of old landfills appeared in Germany in 1970s. On major landfills the wastes were deposited without taking into account the needs of environmental protection (Altlasten-Handuch, Teil I, II 1996). First scientific research was done referring mainly to getting harmful substances into ground waters. Partially, terrifying results of pilot studies, at

the end of 1980s, forced decision makers to make inventory of old landfills. On the whole area of the Federal Republic of Germany there were 100 000 such landfills.

German methods of the estimation of environmental risk from old landfills is based on several steps of threat estimation. The starting point is the assessment of threat in the source of pollution (landfill) defined based on the information on the composition of wastes, type of the landfill, time of deposition, way of exploitation and sealing the landfill and the actions limiting the propagation of pollutants. Further basic routs of the migration of pollutants are considered in the form of indexes modifying the risk. The results are presented on graphs in the point scale for higher and higher "levels of evidence" defining the accuracy of information. Information is mainly obtained through questionnaires, and the assessment is based mostly on description scales. General guidelines how to deal with the landfill depend on the situation on the graph and point score.

Similar approach is presented by the guidelines made by the Environmental Agency UK (Guidelines for Environmental Risk Assessment and Management — materials of Environmental Agency UK, Risk Prioritisation Methodology for sites of potentially contaminated land). The assessment is based on the data obtained in a digital form and a similar as in the previous example algorithm of multi-stage risk estimation is used. The assessment is however more detail, also quantitative data and digital databases are applied. The assessment is made with the use of digital maps and decision supporting systems.

The selection of algorithm, parameters and scale of grades for the Polish conditions will depend on the available data or the possibilities to obtain them, which due to previous neglect is practically impossible (Kozakiewicz, Mikołajczak 2003). Available solutions can't be transferred into Polish conditions in practice.

2. Methodological premises of the estimation of environmental risk from landfills

To assess the risk and classify the objects requiring repairing measures the given below mathematic formula has been created. This formula refers to the solutions used in the methods supporting decision making process (mainly for landfills) in Great Britain, Germany and USA (Repelski 1998).

In the article the following formulae defining the environmental risk R were proposed:

$$R = T \cdot (Z + W + P) \tag{1}$$

where:

- R — synthetic index of environmental risk,
- T — the index of nuisance made by the source,
- Z — parameter considering the time of landfill exploitation,
- W — parameter considering the migration of pollutants through the rock mass and ground waters,
- P — parameter considering the migration of pollutants through the surface waters.

3. Risk Estimation Algorithm

Environmental policy of the state for 2003—2006 regarding the perspectives for 2007—2010 is a consequence of regulations written in the Law of Environmental Protection. Environmental policy for these years is the up-dating and adding details to the long term "Environmental Policy of the State II" that in 2001 was accepted by the Parliament (Sejm and Senate). In art. 18 of "Policy II" it was stated: *Because of the transformation of Polish economy into market economy, in economic policy and the policy related to environmental protection "polluter-pays-principle" will be applied. This would mean putting the whole responsibility, including material responsibility for the consequences of pollution and/or other environmental problems on the perpetrator — i.e. the units using environmental resources.*

The index of the nuisance caused by the source (in formula (1) parameter *T*) should cover the kind of deposited wastes, amount of deposited wastes and the nuisance they cause to the environment. A proposed method of estimating index *T* should give an objective answer to the question: "Which of compared landfills causes potentially greater environ- mental threat than others?".

According to the notes of "Policy II" it has been state that at the estimation environmental risk for landfills the index of nuisance made by the source *T* can be objectively defined as money paid by functioning economic enterprises (active landfills) and theoretical enterprises (inactive landfills) as fee for the use of environment. It has been decided that parameter *T* will be defined according to the formula:

$$T = w \cdot op \tag{2}$$

where:

w — the amount of deposited wastes,

op — fee for the deposition of wastes, updated by the Enactment by the Council of Ministers on the fees for the use of environment (charge rates are given in the Enactment by the Council of Ministers of March 18, 2003 on fees for the use of environment, Dz.U. 03.55.477 of March 31, 2003).

To justify such an approach one should explain that the State — when assessing the nuisance wastes (of every kind — both solid and liquid) make — establishes individual payments for waste deposition eliminating subjective approach of a person estimating the risk). Such a definition of index *T* is definitely better than the estimation of its value with an expert method. This also allows objective assessment of the nuisance made by landfills — both active and inactive — regarding both the amount of deposited wastes and the kind of wastes.

Four technological aspects are particularly important for the scale and range of the environmental impact of landfills:

— amount and kind of deposited wastes (parameter *T*),

— active and passive time of the functioning of the landfill (*Z*),

— sealing the bottom and scarps of the landfill (*W*),
— sealing the bowl of the landfill and its final reclamation (*P*).

Three among the four aspects which were parametrically put into the formula (1), in a drastically differently decide on the effects of landfill exploitation on environment. The most important is sealing the bottom and scarps of the landfill and its bowl. The author reflected that by giving different ranks to this.

Initially it was proposed that the weights if the mentioned above parameters (technological aspects) were the following:

— time of the functioning of the landfill (*Z*) — 0.2,
— sealing the bottom and scarps (*W*) — 0.5,
— sealing the bowl of the landfill (*P*) — 0.3.

The time of the functioning of the landfill first of all reflects the concentration of effluents; *the younger landfill the greater concentration*. In the specialist literature the concentrations of the effluents from municipal and industrial landfills are presented in the time relationship. The weight of *Z*, reflecting the time of the functioning the landfill will be calculated from the formula:

$$Z = 0.2 \cdot N_T/N_1 \tag{3}$$

where:

N_T — the concentration of the substance characteristic for a given landfill in time *T*,
N_1 — the concentration of the substance characteristic for a given landfill for the moment of the appearance of the substance.

Sealing the bottom of the landfill will be represented by the amount of water I_u infiltrated from the landfill to the ground. If the landfill is fully sealed (according to the requirements of the Enactment of the Minister of Environment "*Detail requirements for the localization, construction, exploitation and closing of individual types of landfills*" Dz.U. 2003.61.549) then $I_u = 0$. If it is not sealed — then $I_u = 0.3$, which reflects average amount of precipitation infiltrating to the landfill. Intermediate solutions in sealing the bottom of the landfill modify I_u value.

$$W = 0{,}5 \cdot I_u \tag{4}$$

Sealing the bowl of the landfill and reclamation will be represented by the amount of water I_r infiltrating to the landfill. If the bowl is fully sealed then $I_r = 0$. If it is not sealed — then $I_r = 0.3$. In case of partial sealing of the bowl I_r = ratio of the uncovered part of the bowl to its total surface.

$$P = 0{,}3 \cdot I_r \tag{5}$$

Calculated parameters should be put into formula (1), the amount of wastes should be estimated and this way the payment for their deposition should be established, which will enable us to find the index of environmental risk (*R*).

Conclusions

The synthetic index of environmental risk (R) for a big urban landfill of municipal wastes will always by a few times bigger than the index calculated for the landfill working for a small commune (e.g. landfill Barycz for Cracow and landfill for the commune of Słomniki). For these reasons, to asses the nuisance these landfills make for the environment additional two parameters were introduced:

— parameter of the accumulation of wastes U_N, defined as the ratio of the synthetic index of environmental risk (R) to the amount of deposited wastes,

— parameter of the neutralization of wastes U_U, defined as the ratio of the synthetic index of environmental risk (R) to the number of residents served by the landfill.

In Poland there are many landfills of wastes municipal and industrial that have been exploited in an improper and contradict to the European and Polish standards way. There is the need to construct mathematical models to estimate environmental risk of landfills and industrial areas and then classify them in terms of the nuisance they make to the environment and undertake repairing measures.

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SZACOWANIE RYZYKA EKOLOGICZNEGO NA TERENACH ZDEGRADOWANYCH PRZEZ SKŁADOWISKA ODPADÓW

Słowa kluczowe

Unieszkodliwianie odpadów, składowiska odpadów, oddziaływanie składowisk, modele matematyczne, ocena ryzyka ekologicznego

Streszczenie

W przededniu wejścia do Unii Europejskiej Polska stanęła przed koniecznością dostosowania gospodarki odpadami do wymogów unijnych. Warunkiem koniecznym wprowadzenia niezbędnych zmian w funkcjonowaniu składowisk i ich dostosowania do standardów unijnych jest zebranie pełnych informacji o wszystkich istniejących składowiskach w Polsce, aby było możliwe podjęcie działań administracyjnych umożliwiających dostosowanie składowisk do nowych regulacji prawnych..

Zasób wiedzy oraz narzędzi do sporządzania oceny ryzyka środowiskowego ze strony starych składowisk odpadów i zanieczyszczonych terenów przemysłowych jest już bardzo duży. Narzędzia do takiej działalności stosowane w Stanach Zjednoczonych czy Wielkiej Brytanii można znaleźć na stronach internetowych www.nap.edu, a niektóre publikacje na stronie U.S. Enviromental Protection Agency (www.epa.gov) są możliwe do bezpłatnego pobrania. Problem starych składowisk pojawił się w Niemczech w latach siedemdziesiątych na ważniejszych składowiskach, unieszkodliwiano odpady bez odpowiedniego uwzględnienia racji ochrony środowiska, co doprowadziło do pierwszych badań naukowych dotyczących przede wszystkim przedostawania się substancji szkodliwych do wód gruntowych.

Wybór stosowanych algorytmów, dobór parametrów i skali oceny zależy od dostępnych danych lub możliwości ich pozyskania, co w warunkach krajowych dla większości składowisk jest praktycznie niemożliwe.

Dla szacowania ryzyka i klasyfikacji obiektów wymagających działań naprawczych, opracowana została dla warunków polskich formuła matematyczna.

$$R = T \cdot (Z + W + P)$$

gdzie:

- R — syntetyczny wskaźnik zagrożenia ryzyka ekologicznego,
- T — wskaźnik uciążliwości źródła,
- Z — parametr ujmujący czas eksploatacji składowiska,
- W — parametr uwzględniający migrację zanieczyszczeń przez górotwór i wody podziemne,
- P — parametr uwzględniający migrację zanieczyszczeń przez wody powierzchniowe.

W świetle zapisów „II Polityki ekologicznej państwa" uznano, że przy szacowaniu ryzyka ekologicznego dla składowisk odpadów, wskaźnik uciążliwości źródła T może być obiektywnie określony jako kwota wnoszonych przez podmioty gospodarcze opłat za korzystanie ze środowiska.

$$T = w \cdot op$$

gdzie:

- w — ilość nagromadzonych odpadów,
- op — opłata za składowanie odpadów.

Dla pozostałych parametrów zostały zaproponowane proste formuły matematyczne.

W celu określania uciążliwości składowisk dla środowiska zostały wprowadzone dwa parametry:

- parametr nagromadzenia odpadów U_N, definiowany jako stosunek syntetycznego wskaźnika ekologicznego (R) do ilości zdeponowanych odpadów,
- parametr unieszkodliwiania odpadów U_U, definiowany jako stosunek syntetycznego wskaźnika ryzyka ekologicznego (R) do liczby mieszkańców obsługiwanych przez składowisko.