INFILTRATION ASSESSMENT ON THE BASE OF RESULTS OF LONG TERM LYSIMETRIC OBSERVATION IN NATURAL HYDROLOGICAL CYCLE

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Abstract
Coal-mining waste dumps significantly influenced on aquatic environment. They cause changes in water quality on the region of their deposition. These changes are due to leaching of the soluble compounds from the wastes, caused by infiltration waters. The paper presents detailed studies of the results of long term (1984–2001) lysimetric observation in natural hydrological cycle. Lysimeters were filled up with coal mining wastes from Szczyglowice colliery (Upper Silesian Coal Basin). Since 1984 the lysimeters have remained in natural atmospheric condition including natural recharge from precipitation. Leachates from these wastes and precipitation water were sampled and analyzed every two weeks. On the base of this data was assessed effective infiltration coefficient for two lysimeters. In one of them (SM-1) were fresh coal mining wastes and in the second (SM-2) were 10 years old wastes. Effective infiltration coefficient for lysimeter SM-1 is 0.77. It is higher then effective infiltration coefficient for lysimeter SM-2 (0.62) and it is caused by different term of weathering processes.

Introduction

Recharging infiltration is the process of seepaging water coming from rainfall, watercourses, superficial reservoirs and condensation of steam from area to vadose water zone, and next (after lost part of this waters to atmosphere) seepaging to saturated zone (5).

The infiltration is the one of basic elements of water balance, which also indirectly decides about degree of water environment hazard from waste dumps. Infiltration waters play a substantial role as a solvent of substance which are leach out from waste dump to groundwater, so infiltration process plays essential role in prognosis of influence coal-mining waste dumps (which are real or potential pollution source) on water environment (12,14).

Estimation of the quantity of infiltration recharge waters to waste dump can be done using classical, hydrological method:

- Runoff analysis with separation of underground (6,11);
- Infiltrometers investigation (1,2,8);
- Basis of connection between rainfall and fluctuations groundwater table if groundwater table exist in waste dumps (10);
- Basis on research of moisture profiles vadose water zone (3);
- Basis on lysimetric study (4,17,7).

In this paper rate of infiltration was estimated using lysimetric investigation (which is in progress since 1984) in natural hydrological cycle on experiment area of Department of Hydrogeology and Water Protection AGH – University of Science and Technology in Kraków.

Methods

Column investigation in natural hydrological cycle is continuing in the Department of Hydrogeology and Water Protection AGH since 1984 (14,15,16).

Figure 1: The object model situated at the AGH in Kraków – lysimetric observation in natural hydrological cycle (phot. B.Komenda-Zdechlik)

This object model contains four wells. In three of them are installed lysimeters, in four one occurs tanks for leachates.

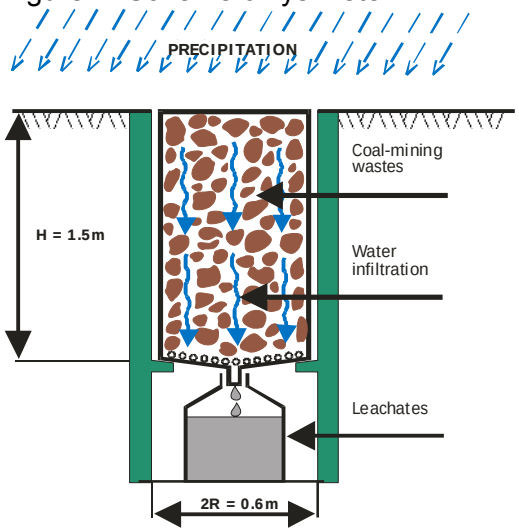
Two of the lysimeters (SM1, SM2) were filled up in 1984 with coal mining wastes from Szczygłowice colliery, which represents Upper Silesian sand series. The lysimeter SM1 was filled up with fresh coal mining wastes, and SM2 – with 10 years old wastes from coal mining waste dump Smolnica (the wastes which were weathered on the dump) tab. 1.

Table 1: Characteristics of wastes which are placed in lysimeters. Technical data of lysimeters

Parameter	**Lysimeter SM1**	**Lysimeter SM2**
Litostratigraphic series	Upper Silesian sand series	
Age of wastes	0 year	10 years
The date of filling lysimeters	1 XI 1984	1 XII 1984
The date of first effluent	14 V 1985	31 I 1985
Physical characteristics of wastes		
The moisture W_n [% wag.]	4.67	7.24
The density volume ρ [g/cm^3]	1.73	1.83
The density of soil ρ_d [g/cm^3]	1.65	1.71
Technical data of lysimeters		
The length L [cm]	150	
The diameter 2R [cm]	60	
The area F [cm^2]	2830	
The volume V [dm^3]	424.5	

Lysimeters are open on the top, so water from precipitation can flow through the coal-mining wastes and can be gathered into the tanks (fig.2).

Figure 1: Scheme of lysimeter

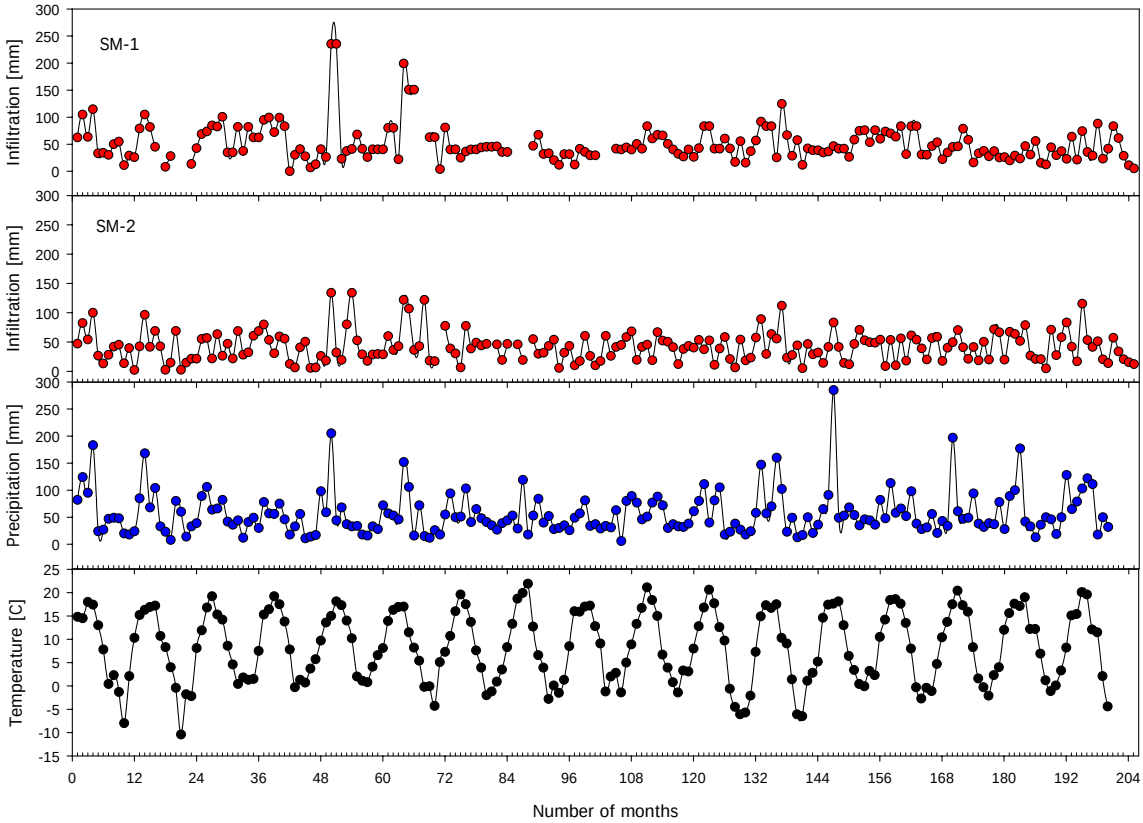


In continuous way (every two weeks) since first effluent from lysimeters (17 years) are measured volumes and physical and chemical indicators (summary 40 elements are analyzed).

Results

Figure 3 presents changes of the quantity of infiltration for both lysimeters, and changes of temperature and precipitation for the analyzed period: from 14.05.1985 (first effluent from lysimeter) to 15.05.2002 (experiment in progress). Mean water infiltration, calculated on the base of 17-years observations is 0.5 m/year for lysimeter SM1, and 0.42 m/year for SM2.

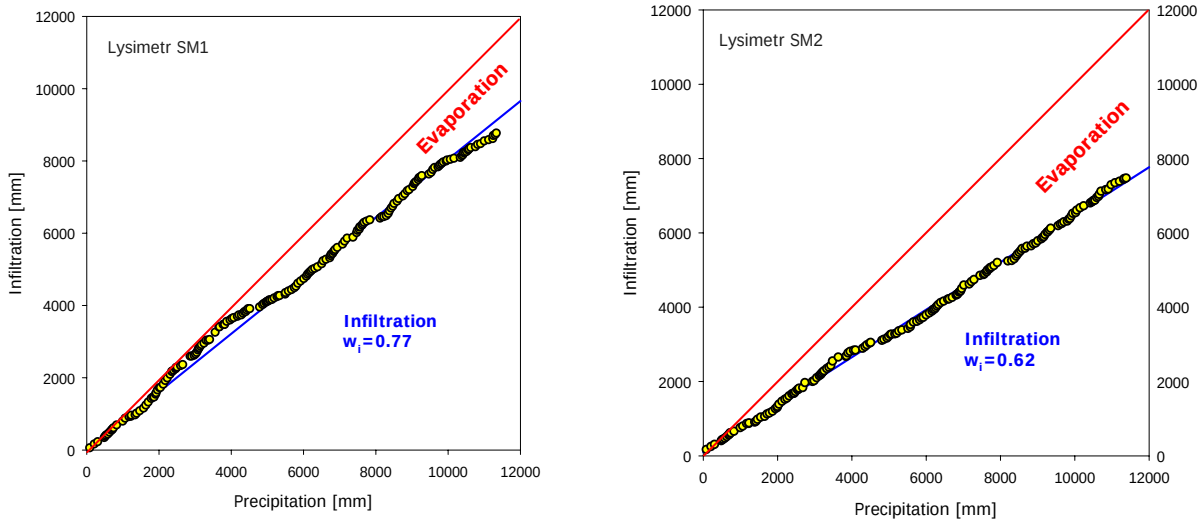
Figure 3: Mean monthly values of infiltration, precipitation and temperature for the analyzed period (1985-2002)



For both lysimeters were created charts of infiltration in function of rainfall (fig. 4) and was calculated reacharge infiltration coefficient (w_i) as a proportion of infiltration (I_e) and rainfall (P) (9).

$$w_i = Ie/P.$$

Figure 4: Estimation of infiltration coefficient on the base of long-term lysimetric observation in natural hydrological cycle (1985-2002)



Conclusion

For lysimeter SM1 (filled up with 17 years old coal mining wastes) recharge infiltration coefficient is 77%, but for the lysimeter SM2 (filled up with 27 years old coal mining wastes) - 62%. This investigation indicate high contribution of infiltration in view of evaporation (fig. 4).

Effective infiltration coefficient calculated for lysimeter SM1 on the base of initial results (from first 8 months of experiment) was $w_i = 0.6$, and for lysimeter SM2 (on the base of data from first 7 months of experiment) — $w_i = 0.56$ (13).

The results indicate that amount of infiltrated water increases in time. The higher amount of infiltrated water, the higher charge of contamination transported this way to the groundwater. Mean year infiltration 0.47 m (calculated for both lysimeters) indicates that one time change of water in the waste dump of thickness 20 m, natural moisture 6 weighted % will last about 4.3 years. So process of leaching of soluble compounds from waste dumps is very slow, and long time lasting (14).

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