The influence of sea surges on the increased inflow of pollutants from the landfill.

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Abstract In Szczecin there is an old waste landfill located close to the Odra River, whose building begins after the Second World War and at this place communal wastes were stored without any control. The waste was closed in 1970 year. The contaminations stay in the ground. From investigation arise, that the contaminations are still mixing with groundwater and migrates. The groundwater flows directly to the river Odra and wash out the contamination to the river. In previous research author estimated pollutant load, which in this way is introducing the river. In particular case, when see surge occurs it drains off lump contaminations. The surge from the sea induces back water curve (about 1 m above normal level) in the waste area. In this case water from the river enters the wastes area, flushing inside the landfill body. When the surge goes out, it makes significant difference in water level between river and the waste. This significant difference level induce sudden outflow of water from the waste, bringing contaminants, to the river. The subject of study is determination of pollutant load introduced to the river in this way.

Key words waste landfill, groundwater model, contamination, river influence

INTRODUCTION

When the influence of underground water filtration on the environment is estimated, it is of fundamental significance to identify exactly water-ground conditions and to determine changes and directions of pollutants migration. The analyses, supported by computer calculations, permit us to simulate quickly underground water flow in different conditions, facilitate to estimate the situation and to make predictions for determining the most effective methods of preventing filtration effects.

The simulation of underground water flow in the examined area has been carried out using the model of plane flow. The choice of two-dimensional plane model was dictated by ground-water conditions allowing to pass over the component of filtration velocity in vertical direction. For numerical simulations the computer program SPRING was used. In order to carry out preliminary calculations a model consisting of 1066 nodes and 1127 elements has been created.

NUMERICAL CALCULATIONS OF PASSIVE POLLUTANT CONCENTRATIONS IN THE LANDFILL AREA UNDER STEADY CONDITIONS.

To avoid problems connected with the so-called numerical dispersion, the basic net as been refined to 6537 elements and 3468 nodes.
Assuming that passive and stable pollutants are emitted from the landfill area (the source of contamination), the distribution of the field of relative pollutant concentrations \( c_w \) for the examined area has been determined. The term of relative concentration \( c_w \) means the percentage ratio of pollution concentration at any point of the examined area \( c \) to the concentration in the source \( c_0 \). The advectional movement as well as longitudinal and transverse dispersions have been taken into account in the calculations. The processes of retardation and decomposition as well as biodegradation have not been taken into account in the examinations. For the purpose of calculations the assumption has been made that the coefficient of longitudinal dispersion \( \alpha_x = 30 \text{ m} \) and the coefficient of transverse dispersion \( \alpha_y = 0.1 \cdot \alpha_x = 3 \text{ m} \). Using the data presented in the literature (Kinzelbach, 1992) where the scale of the dependence of longitudinal dispersion ability on the length of the examined section has been given.

In the analysis of contamination propagation for the model of two-dimensional plane flow the equation of advection-dispersion has been used. The calculations have been carried out for the period of 12 years, counting from the beginning of emission, for the conditions of steady-state underground water flow. After the passage of about 4 years the changes of the field of concentrations were so small that it could be accepted that a steady state occurred after this time.

**CALCULATION METHODICS OF POLLUTANT CONCENTRATIONS CHANGES**

The distribution of contamination has been calculated taking into account the processes of advection and dispersion as being dominant for the examined kind of contamination. The detailed results of the calculations of the distribution of contamination concentrations for the field of steady-state filtration were described and presented in the previous study (Kowalów, 2000). In order to calculate the stream of contamination mass coming to the river it is to calculate the function of contamination concentration \( c(t) \) and the value of discharge \( q(t) \) at any place \((x, y)\).

The stream of contamination can be expressed by the equation:

\[
\varphi(t) = q_n(t) \cdot c(t)
\]

where:

- \( q_n(t) \) – the component value of the vector \( q \) normal to the border at the point with the coordinates \((x, y)\)

For any point at the area border the function \( \varphi(t) \) can be expressed in the form of:

\[
\varphi(t) = \sqrt{q_x^2 + q_y^2} \cdot c(t) \cdot \cos(n, q)
\]

where:

- \( q_x, q_y \) – the components of the vector \( q \) in the direction of the axes \( x, y \);
- \( \cos(n, q) \) – the angle between the vector \( q \) and the vector normal to the border at the point \((x, y)\).
If \( q \) is perpendicular to the common order between water-bearing layer and stream, as in Fig. 1, then \( \cos(n, q) = 1 \) and therefore:

\[
\varphi(t) = \sqrt{q_x^2 + q_y^2} \cdot c(t)
\] (3)

The integration of concentrations in order to obtain the load is carried out along equipotential lines. Therefore it can be written:

\[
\Delta L = \varphi(t) \cdot \Delta l \cdot \Delta t \cdot m = c \cdot q \cdot \Delta l \cdot \Delta t \cdot m
\] (4)

To find the pollutant load over the section from A to B (rys. 1) it is to calculate the sum:

\[
\Delta L(n) = \Delta t \cdot \sum_{i=1}^{i=n} [c_i \cdot q_i \cdot \Delta l_i \cdot m_i]
\] (5)

As the subject of this study also is the analysis of pollutant inflow to the river, so the summing up presented above can be related to the river bank.

The load \( (L_R) \) in the river at the initial point is equal to:

\[
L_R = Q_R \cdot c_{R0} \cdot \Delta t
\] (6)

In the area \( \Delta l \) the load \( \Delta L_1 \) comes additionally into the river during \( \Delta t \):

\[
\Delta L_1 = q_1 \cdot c_1 \cdot \Delta l_1 \cdot \Delta t \cdot m_1
\] (7)
So the total load amounts to:

$$L_R + \Delta L_1 = (Q_R \cdot c_{R0} + q_1 \cdot c_1 \cdot \Delta l_1 \cdot m_1) \Delta t$$

This load falls to the stream $Q$ amounting to:

$$Q = Q_R + q_1 \cdot \Delta l_1 \cdot m_1$$

or to the water volume in which the new total load will dissolve. This volume is equal to:

$$V_R = (Q_R + q_1 \cdot \Delta l_1 \cdot m_1) \Delta t$$

So the pollutant concentration in the river at the cross section I amounts to:

$$c_1 = \frac{L_R + \Delta L_1}{V_R} = \frac{Q_R \cdot c_{R0} + q_1 \cdot c_1 \cdot \Delta l_1 \cdot m_1}{Q_R + q_1 \cdot \Delta l_1 \cdot m_1}$$

At any cross section $N$ of the river we obtain:

$$c_N = \frac{Q_R \cdot c_{R0} + \sum_{i=1}^{i=n} (q_i \cdot c_i \cdot \Delta l_i \cdot m_i)}{Q_R + \sum_{i=1}^{i=n} (q_i \cdot \Delta l_i \cdot m_i)}$$

Assuming that the inflow of underground water to the river is small in comparison with the flow in the river $$\left(\sum_{i=1}^{i=n} (q_i \cdot \Delta l_i \cdot m_i) \ll Q_R\right)$$ and the concentrations of pollutants coming from underground water are significantly greater than the concentrations in the river, the equation can be written in the following form:

$$c_N = c_{R0} + \frac{1}{Q_R} \cdot \sum_{i=1}^{i=n} (q_i \cdot c_i \cdot \Delta l_i \cdot m_i)$$

In order to allow us to determine the value of the load inflowing the watercourse, the author has elaborated a program of balance calculations, extending the software package SPRING.
A MODEL DETERMINATION OF THE REDUCTION OF THE CONCENTRATIONS OF POLLUTANTS MIGRATING FROM THE LANDFILL POMORZANY IN TRANSIENT CONDITIONS CAUSED BY FLOOD-WAVE IN WATERCOURSE

The phenomenon of the influence of water level change in the river on the states of underground water is described widely in the literature.

Basing on the model of the transport of passive and stable pollutants in steady-state conditions for selected landfills without any securing equipment, the analysis of the effect of flood-wave in the river on the change of satiation curve for the model taking into account securing constructions has been carried out.

As an example the case of the use of a vertical wall with the following parameters has been chosen:

![Fig. 2](image_url)

**Fig. 2** The curve of the change of concentration at the selected node for transient flow – the vertical wall in the period of 120 days.

Above the curves of the change of concentrations for the selected nodes calculated for 120 days from the beginning of the development of long flood-wave (time of rise/time of go down counted in days = 12/12) are presented. When flood-wave is staying in watercourse, the concentrations are falling to reach their minimal values in the interval of 120 days which correspond to the time of appearing of flood-wave culmination (12th day from the beginning of flood-wave staying). After flood-wave culmination is subsided, the concentrations rise but do not reach their initial values. After the passage of 120 days the values of concentrations are still high.

Comparing the results concerning the use of the vertical wall, it can be noted that this method reduces effectively the concentrations which reach their minimal values after the passage of about 5 years. Therefore the time/period/ of calculations has been prolonged for 2040 days (about 5,5 years). The result of calculations is presented below.
Fig. 3 The curve of the change of concentration at the selected node for transient flow – the vertical wall in the period of 204 days.

The concentrations reached after the passage of about 5 years from the beginning of the operation of the vertical wall reach the values comparable with those obtained for the transport under steady-state conditions. The influence of flood-wave on the changes of satiation curves disappears after the passage of about 250 days.

At the time point of 204 days from the beginning of flood-wave the disturbances of flow field and concentrations field for the variants with securing constructions have not reached the values obtained for steady-state conditions.

CONCLUSIONS

The application of the numerical model permits, unlike analytical computational methods, to take into account simultaneously many factors effecting on the hydraulic conditions of water flow and pollutant migration. It is possible to analyse quantitatively the effect of the selected securing method on the reduction of negative influence of landfill on underground water as a whole.

In each of the assumed solutions one obtains the field of flow and pollutant concentrations before and after the securing construction has been made. This permits to determine water volumen and pollutant concentrations flowing from the landfill. The numerical model makes it possible to analyse the course of this phenomenon over time until steady-state conditions are reached. Practical calculations show, within the calculations in transient filtration conditions, for example caused by raised-water stage in a surface stream in the landfill area, that a long time - from some months to many years - is required until the values of pollutant concentrations become stabilized. Individual, changing over time phases of the field of flow can be obtained from the calculations. It is to state that the model gives good results also for transient motion conditions caused, for example, by rise of water in the stream.

REFERENCES