Earth Sciences
2022; 11(1): 1-5
http://www.sciencepublishinggroup.com/j/earth
doi: 10.11648/j.earth.20221101.11
ISSN: 2328-5974 (Print); ISSN: 2328-5982 (Online)

Surface and Groundwater Pollution as a Result of the Technogenic Impact

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To cite this article:
Razinkov Nikolay Dmitrievich, Ovchinnikova Tatyana Valentinovna, Kalach Andrey Vladimirovich, Smolyaninov Vladimir Mitrofanovich, Arifullin Evgeniy Zaudyatovich, Nekrasova Anastasiya Olegovna. Surface and Groundwater Pollution as a Result of the Technogenic Impact. *Earth Sciences.* Vol. 11, No. 1, 2022, pp. 1-5. doi: 10.11648/j.earth.20221101.11

Received: November 17, 2021; **Accepted**: January 14, 2022; **Published**: January 21, 2022

Abstract: Old graves site of MSW (municipal solid waste) remain active as environmental source of pollution. The purpose of our research is the desire to study and improve an ecological aspect including the topic of surface and groundwater. Currently, the main waste disposal site for the Voronezh millionth city is a landfill located on the right bank of the Don near the rural area of the Devitsa in the Semilukskiy district of Voronezh region. This landfill of MSW began to be used in 2012. It is located closer to former used landfill closed in the same year. The former and now existing landfills were created on the site of previously worked quarries for the extraction of clay and sand for the construction industry. The landfill for receiving solid household waste (MSW – there was such a name in these years) was started to be used after excluding the significant comments of the place of former used Sredniy quarry mine in 1993. Waste collection began to work in 11.11.1993. The landfill accepted waste for disposal until 16.03.2012. Moreover, the situation with the storage of waste was considered as an emergency over the past few years. Since, according to the project, the landfill was overfilled by 30%! The main purpose of this article is to assess the intake of pollutants into groundwater from a closed landfill at the Sredniy mine in the Semiluksky district of the Voronezh Region and to determine their release into the Don River through the aquifer. The report of the monitoring activities of LLC Voronezhgeologiya will be used in the context of research. As a result, solutions of reducing the pollution impact on this area will be identified.

Keywords: Storage, Man-made Pollution, Waste, Landfill, Filtrate, Groundwater, Natural Environment

1. Introduction

The closed area of municipal solid waste is located in the territory of former piles of mine Sredniy and occupies an area of 38,82 hectares. In the last 18,5 years of MSW management activities, 28,695 mln m^3 of municipal and industrial waste (4, 5 classes) that 5,739 mln t (by weight) were located there. The emplacement of the landfill stood at 130%. There were 8 constructions of observation boreholes. Wastewater pollution monitoring has never been under control before and after. And it is over last 9 years. There was not air pollution control. Before the closure of the landfill (approximately in its central part), a filtrate lens was formed and occupied up to 30% of the entire area of the landfill.

The impact of the landfill on the natural environment is largely due to the pollution of ground water. In turn, these are unloaded into a nearby location at a distance of 3,575 km (along the trajectory of the main volume of the filtrate) in the Don (Figure 1).

The emerging area of pollution under the landfill of solid industrial and household waste as the geological environment is local. But it is characterized by a high intensity of the ongoing pollution of groundwater (more than hundreds of MPC). Hydrogeologists usually attribute this level of pollution to the second stage as the most dangerous.

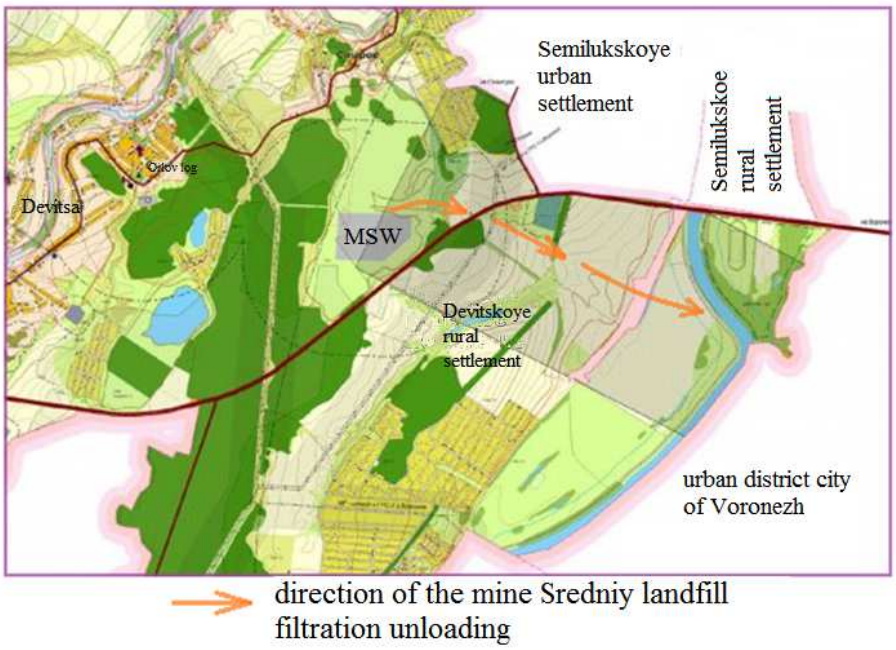

Figure 1. *The contingency plan explaining pollution of the river Don.*

2. Research Materials and Methods

The study in the context of research is based on the results of monitoring activities of LLC Voronezhgeologia. These observations were carried out for 12 years (from 1999 to 2011) [1].

The structure of the geological environment for groundwater pollution fixation were installed during the construction process of monitoring well`s network on geological habitat under municipal solid waste area in the mine Sredniy (Figure 2).

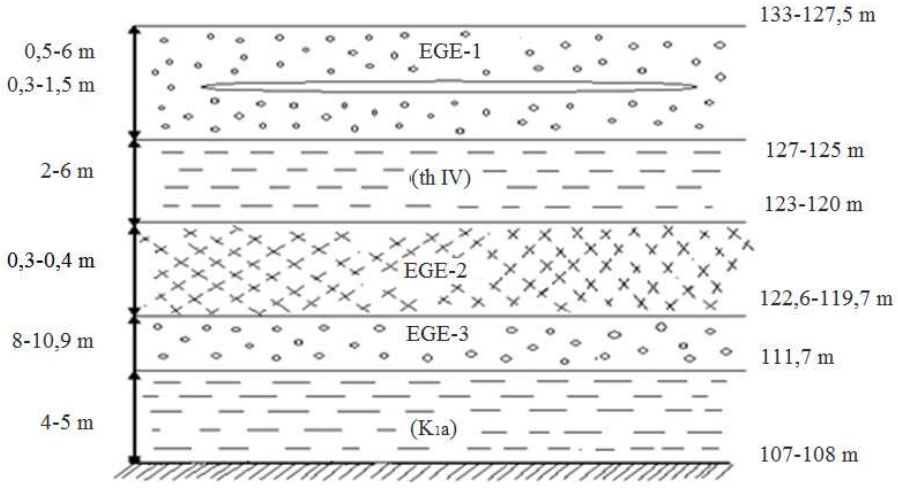

Figure 2. *The geologic units on the area of municipal solid waste (territory of former the mine Sredniy) in the Semilukskiy district.*

At the same time, two aquifers are clearly identified:

1) 1-st (thIV) in the height range from (127 – 125 m) to (123 – 120 m) with a water-bearing rock thickness of 2 ÷ 6 m;
2) 2-nd (K_{1a}) with a water resistance mark at 107 – 108 m of a Baltic Sea Geographic Information System and with power of 4 ÷ 5 m.

We will characterize the aquifers based on the problem of discussion as the assessment of the spread of pollution coming from the landfill in the Sredniy mine towards the Don.

The aquifer thIV: water-bearing rocks are sands with gravel and pebbles additions; the filtration coefficient of watered (underground) sands is $K_f = 5 \div 10$ m/day.

The second aquifer is called the Aptian terrigenous horizon (K_{1a}) in the considered geological environment. The sand and gravel deposits composing this horizon are watered there; for the considered soils, the Kf has a value in the range from 1 to 15 m / day [2-4].

The considered horizons are fed by atmospheric precipitation and water entering to the aquifers during snowmelt from the considered ground feeding basin.

According to the physical and geographical zoning, the territory of the landfill is confined to the Oka-Don plain and corresponds to its geological features, topography, climate and soils.

The landfill is located between the Drainage Rivers (the Devitsa-2 km and the Don -3,575 km with altitudes of 120-169 m). The landfill is placed at a relatively short distance from residential areas:

1. 0,7 km to gardeners' non-commercial partnership Aluminiy in Semilukskiy district;
2. 1,2 km to p. Porechye of Devitsky rural settlement in the Semilukskiy district;
3. 1,3 km to Devitsa in the Semilukskiy district;
4. 1,4 km to Yuzhny in Semiluki;
5. 4,0 km to Tenostiy in Voronezh;
6. 4,2 km to Pervoe Maya in Voronezh.

The landfill is actually surrounded by residential areas located at a distance of 0,7 to 4,2 km. Single wells are used for water supply to the closest countrysides.

Precipitation such as rain and snow is the main conductor of pollutants, surface and ground water sources of pollution.

There was an emergency situation caused by the highly toxic filtrate overflow from the landfill ground to the beyond territory and from there to the aquifer before the closure of the landfill. At that time, the insulation screen apparently had not provided protection for underground water from pollution.

The surface of the closed polygon ground was originally covered with an anti-filtration screen. The stored waste with overflow formed a truncated pyramid with a height to 30 m. The composition of the buried MSW is quite varied: food residues, paper, cardboard, wood, glass, scrap metal, textiles, rubber, plastic, synthetic and other substances.

To receive the liquid effluents flowing from under the body of the landfill (filtrate), main (V =9,5 ths. m^3) and additional (V = 5,6 ths. m^3) settling tanks were built on the western flank in the lowered areas of the terrain. Due to the large amount of released filtrate and frequent emergency breakouts, an emergency storage tank was additionally constructed in 1999 (V = 7.22 thousand m^3). All structures for receiving filtrate had clay rolled screens with low filtration properties with a capacity of 0,5 m. However, a survey conducted in 2011 found that the problem of complete isolation of the filtrate remained unresolved. There was filtrate slurry with a length of about 120 m, a width of 40 m and a capacity of 6 m on the opposite (eastern) flank of the MSW landfill at the end of the dammed hollow on the date of the screening. An accumulation of liquid filtrate was formed on the southern flank of the MSW landfill in a low area. Its power reached 2m. Unscheduled filtrate accumulations were located on unprotected sandy soils and easily infiltrated down to the clay layer (Figure 2).

The corresponding analytical work was carried out during the monitoring of the state. This process is aimed at fixing ever-increasing pollution and predicting risk assessments for environmental authorities. Ultimately, such activities accelerated the decision to close the MSW landfill at the Sredniy mine, which had served its design term. Unfortunately, monitoring of the geological environment pollution has been discontinued in the area of the landfill site since 2012. This approach is difficult and distressing case because, according to the established rules, the landfill was not recultivated [5-7].

Last years of the MSW landfill activities water samples from monitoring wells indicate the second stage of the ongoing process of pollution in the Sredniy mine. The table below shows the maximum recorded pollution of aquifers in 2010-2011.

Table 1. *Soil filtrate contamination results of the monitoring process before the closure of the MSW landfill on the area of the Sredniy mine in the Semiluksky district.*

Water-bearing layer	Dry balance	General hardness	Carbonate hardness	Oxidizability	Ammonium ion
	Concentration, milligram / decimetre ^{3} MPC (maximum permissible concentration)				
th IV	1444	19,95	16,99	66,3	17,40
	1,4	2,9	2,4	13,3	8,7
K_{1a}	2950	27,03	27,50	76,44	120,0
	3,0	3,9	3,9	15,3	60,0
Value MPC	1000	7 mol/m^3	7 mol/m^3	5,0	2,0

Water-bearing laye	Nitrates	Iron	Manganese	Boron	Fluorine
	Concentration, milligram / decimetre ^{3} MPC				
th IV	4,8	96,4	0,84	0,32	1,74
	0,1	321,3	32	0,6	1,2
K_{1a}	3,2	103,6	5,98	1,87	4,11
	0,1	345,3	59,8	3,7	2,7
Value MPC	45,0	0,3	0,1	0,5	1,5

There is a simple model for the migration of polluted water into the reservoir to estimate the time of receipt of filtrate from the actually abandoned landfill. The "piston displacement" model is used because of the insufficient knowledge of the geological environment on the trajectory of its arrival indicated in Figure 1 [8].

3. Results and Discussion

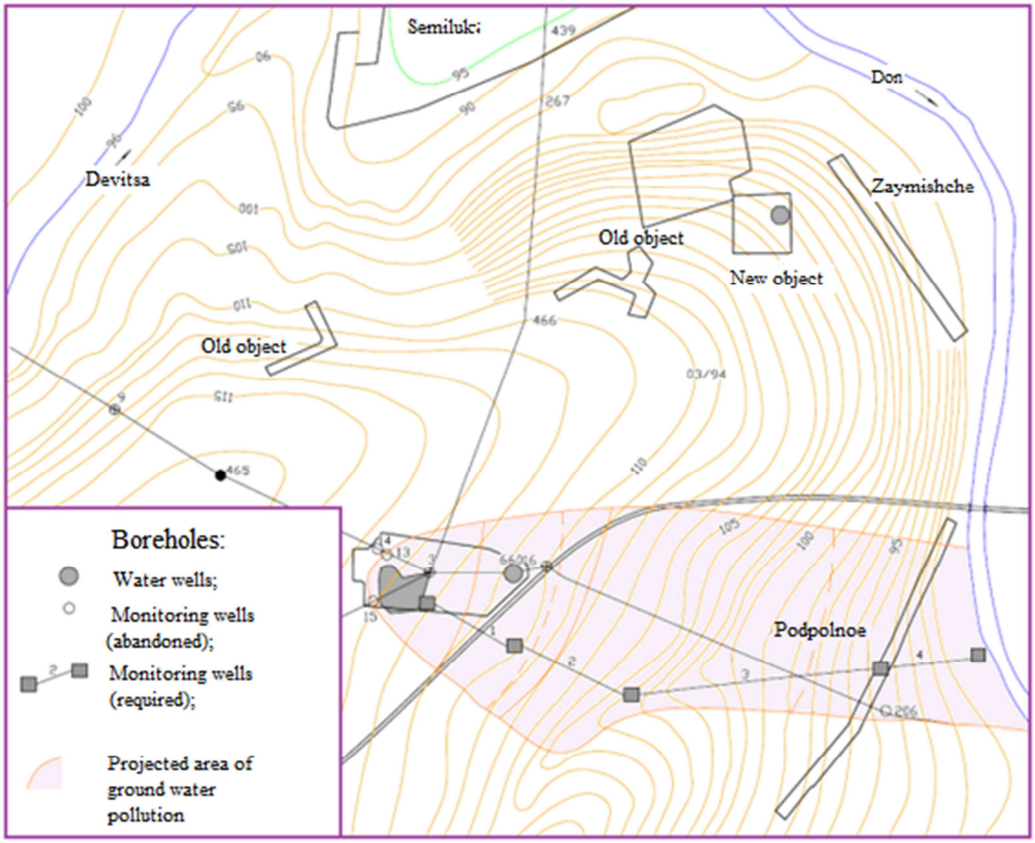

Figure 3. *An area of predictable liquid fraction yield pollution from MSW landfill in the mine Sredniy of the Semilukskiy district.*

The developed project of a 2011 new landfill [9-14] was launched in 2012 next to the solid waste landfill in the Sredniy mine. At the same time, an assessment was made of the rate of propagation of environmentally hazardous filtrate penetrating through the sole of the MSW landfill into the water-bearing landfill. The calculation was also made using the "piston displacement" model. The true propagation of the pollution front in the direction of the Don River was determined by analyzing detected patterns of pollution movements: Vnat is 0,102 m/day. Based on this information, it is possible to estimate the beginning of the approach of pollutants from the filtrate of the MSW landfill in the Sredniy mine to the Don and the time of the beginning of the maximum concentrations of pollutants in the aquifer discharged into the Don (Figure 3).

It was established that the polluted groundwater of the Aptian terrigenous horizon will approach the Don River by 2022 and the maximum concentrations of pollutants will be since 2089 as a result, i.e. a polluted groundwater front will have become.

Similar analytical work was also studied by scientists in the Voronezh Region. The revealed pollution trend generally coincides with the previously made conclusions studied by geoecologists of Voronezh State University in the article about problems of geological environmental pollution [15]. At the same time, they noted that in order to clarify the identified trends of groundwater pollution, it is necessary to organize an assessment of the aquifers filtration parameters studies.

4. Conclusion

Estimates of contamination in ground water from the closed landfill of MSW in the mine Sredniy of the Semilukskiy district of Voronezh region and its planned exit on the aquifer in the Don River require fast decisions:

1) The restoration of the monitoring network directly at the abandoned now landfill;
2) The establishment of monitoring wells on the path of the expected filtrate movement in the Aptian terrigenous groundwater horizon (Figure 3).

Design and survey works will have to be carried out in case of confirmation of the pollution promotion calculations. The reserve of time is still available for making decisions to reduce the load of polluted groundwater in the Don River.

The problem of groundwater pollution has become an extremely sensitive problem all over the world in the XXI century. In spite of the huge territories and natural resources Russia is no exception in this case. As it is known, there is a direct link between groundwater pollution and anthropogenic factor. The ability to develop and planning effective environmental protection measures is based on a comprehensive study and monitoring of ground and surface waters.

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