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Study of nitrate concentration in Najaf Abad aquifer using GIS

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Abstract. The effectiveness of in situ sediment capping as a technique for heavy metal risk mitigation in Hyeongsan River estuary, South Korea was studied. Sites in the estuary were found previously to show moderate to high levels of contamination of mercury, methylmercury and other heavy metals. A 400 m x 50 m section of the river was selected for a thin layer capping demonstration, where the total area was divided into 4 sections capped with different combinations of capping materials (zeolite, AC/zeolite, AC/sand, zeolite/sand). Pore water concentrations in the different sites were studied using diffusive gradient in thin film (DGT) probes. All capping amendments showed reduction in the pore water concentration of the different heavy metals with top 5 cm showing %reduction greater than 90% for some heavy metals. The relative maxima for the different metals were found to be translated to lower depths with addition of the caps. For two-layered cap with AC, order of placement should be considered since AC can easily be displaced due to its relatively low density. Investigation of methylmercury (MeHg) in the site showed that MeHg and %MeHg in pore water corresponds well with maxima for sulfide, Fe and Mn suggesting mercury methylation as probably coupled with sulfate, Fe and Mn reduction in sediments. Our results showed that thin-layer capping of active sorbents AC and zeolite, in combination with passive sand caps, are potential remediation strategy for sediments contaminated with heavy metals.

Keywords: GIS; concentration of nitrite; Najaf Abad; groundwater sources

1. Introduction

Underground water is one of the most important natural resources in the world. At present, a significant portion of Iran's water consumption, especially in drinking water, is provided by groundwater resources (Khodaei, 2006). Guo, Fu, Ruan,Ge, Ghao, (2014) have also done research on the quality of water in the rivers of the world, and in their studies concluded that agricultural wastewater is the most important factor in increasing nitrate in the rivers. Sahu *et al*. (2016) in their study assessed the vulnerability of groundwater using a drastic model in the Indian Peninsula region, and using three methods of entropy, parametric sensitivity and fuzzy pattern methodology, to change the weight, they used the main features and analyzed them. Lasagna *et al*., 2016, examined the role of physical and biological processes in aquifers and their importance in vulnerable groundwater pollution to nitrate pollution in the northwest of Italy and considered dilution as the most important factor in nitrate removal. Soliman *et al*. (2017), in their study for the effective management of groundwater resources, used the GIS-based data mining model in the southern province of Procae, Malaysia, and then evaluated the effective factors using the GPM model. Goodarzi *et al*. (2017) investigated the vulnerability of groundwater to nitrate pollution due to agricultural activities in Qazvin aquifer. Their results indicated that 9% of the aquifer is located in the high risk area, and also the soil environment factor has the greatest impact on aquifer vulnerability. Assadi *et al*. (1395) introduced a serious approach to changing the known parameters of vulnerability and their adjustment in urban areas by studying in Mashhad and indicative methods were used to evaluate the correction of parameters, measurement and accuracy of corrected methods by nonparametric correlation.

Energy of the influent must be dissipated at the inlet zone by selecting the best position and configuration of the inlet or using the baffles in the inlet zone (Kerbs *et al*. 1995). The two main types of sedimentation (clarifier) tanks are primary and secondary (or final) settling tanks. In the present study, focus is made on the sedimentation basin in irrigation network. One problem in irrigation structures is sedimentation control at the main entrance to the irrigation network (Shetab-Boushehri *et al*. 2010). A sedimentation basin consists of an oversized section of a canal, built downstream from the canal head works, and its design was based on increasing the canal surface area to reduce the flow velocity low enough to permit much of the fine suspended particles that might otherwise be transported through the canal and be deposited (Vanoni 1975; Vittal and Raghav 1997; Ranga Raju *et al*. 1999). The settled sediments can be removed by mechanical means or flushing. The bigger the basin, the better the retardation of the sediments, but Expenses are higher, dredging must be done more frequently. Therefore, improvement of performance and increasing sediment removal efficiency of sedimentation basins by an alternative method is necessary. The sedimentation performance depends on the characteristics of the suspended solids and the flow field in the basin.

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A common approach for increasing sedimentation basins performance is to use baffles (Tamayol *et al*. 2010). Baffles can interrupt short-circuiting, giving rise to a modified flow field and, potentially, improve the basin performance. Energy of influent must be dissipated at the inlet zone by selecting the best position and configuration of the inlet or by using baffles in the inlet zone (Zhou *et al*. 1992). Baffles are usually placed in the front of inlet opening or built at the bottom of the tank to increase their sedimentation performance (Tamayol etal.2010). A uniform flow field is essential to the efficient performance of sedimentation basin. Baffles enable particles to settle at a constant velocity and in a short period of time. Also the circulation zones between the inlet and outlet of the basin decrease and enhance sedimentation performance. Baffle positioning is essential in dissipating the kinetic energy of incoming flow and reducing chances for occurrence of short circuits (Zhou *et al*. 1992). The baffles act as barriers, effectively suppressing the horizontal velocities of the flow and forcing the particles to the bottom of the basin (Shahrokhi *et al*. 2011a). It must be noted that using baffles without enough caution can worsen performance compared with the tank without a baffle.

Most previous studies have been conducted in primary and secondary tanks (settling tanks). There are a number of comprehensive studies on baffled tanks that investigate their hydraulic efficiency (Tamayol *et al*. 2010; McCorquodale and Zhou 1993; Xanthos *et al*. 2010). Wills and Davis (1962) have studied the effects of transverse and longitudinal baffles (θ=90˚) on the performance of the sedimentation tanks and have shown that the transverse baffles decrease short circuiting. Crosby (1984) observed that a mid-radius vertical baffle extending from the floor up to mid-depth decreased the effluent suspended sediments concentration of the clarifier by 37.5 %. Krebs *et al* (1992, 1995) and Krebs (1995) investigated the effect of inlet and intermediate vertical baffles on the flow field in final clarifiers. Their research was based on experiments, numerical modeling and analytical relations. Energy dissipation is the main objective in designing a primary clarifier inlet. Energy of influent must be dissipated at the inlet zone by selecting the best position and configuration of the inlet or by using the baffles in the inlet zone (Krebs 1995). Bretscher *et al*. (1992) showed that installation of the intermediate vertical baffle was effective on the velocity and concentration fields for a rectangular settling tank. Ahmed *et al*. (1996) studied the effects of the position and height of the baffle (θ=90˚) in a secondary sedimentation tank by the bottom inlet by placing the baffle at three different positions and various heights, qualitatively. The best result was for the case in which an inlet baffle with a height 67% of the total depth was placed in the first 5 % of the channel. After testing many potential raceway design modifications, Huggins *et al*. (2005) noticed that by adding a vertical bottom baffle, the overall percentage of solids removal efficiency increased from 81.8 % to 91.1 %, resulting in a reduction of approximately 51 % in the effluent solids. Tamayol (2005) showed that the best position for the inlet is near the bottom and that the existence of a reflection entrance baffle near the free surface of settling tanks can increase the performance of primary settling tanks. Goula *et al*. (2007) used numerical modeling to study particle settling in a sedimentation tank equipped with a vertical baffle installed at the inlet zone (bottom inlet). They showed that the baffle increased particle settling efficiency from 90.4 % for a standard tank without a baffle to 98.6 % for a tank with an installed bottom baffle. Razmi *et al*. (2008) found that best location of the vertical baffle is obtained when the volume of the circulation zone is minimized or the dead zone is divided into smaller parts, and they showed that this baffle can reduce the size of the dead zones and turbulent kinetic energy in comparison with the no-baffle condition. Shahrohki *et al*. (2011b, 2011c) was performed numerical simulation to investigate the effects of vertical baffle location on the flow field in rectangular primary sedimentation tanks. Based on the smallest volume of the circulation zone and kinetic energy, the maximum concentration of the suspended sediments in the settling zone and the highest value of removal efficiency, theyprovedthat the baffle (using a baffle height-to-depth ratio of b/H=0.18) should be placed between 0.125 and 0.20 (inlet-to-tank length ratio). Razmi *et al*. (2013) investigated the effect of the baffle position on the performance of a primary settling tank experimentally and numerically. Their results showed that the best position of the bottom baffle (θ=90˚) is relatively close to the entrance jet (10-20 % tank length), while the best baffle height is around 25-30 % of the water depth. The effect of baffle angles and position were examined using a 2D model (Flow-3D, 2003) applied to a small-scale, 2-m long laboratory setup (Rostami *et al*. 2011; Shahrokhi *et al*. 2011a, 2012). Right-angled (to the tank base) baffles were most favorable for sedimentation. In addition, it was concluded that, to get high settling performance, the baffle should be somewhere close to the inlet. However the effects of baffle height and optimal baffle configuration were not considered. Dynamic evaluation of water source safety based on fuzzy extension model was studied by Ou *et al*. (2019). Roles of polypropylene beads and pH in hybrid water treatment of carbon fiber membrane and PP beads with water back-flushing were presented by Song *et al*. (2019). The effect of Combined Sewer Overflow on the river system was investigated by Bae wt al. (2020) throughout three preliminary field tests and three main ones. Kim *et al*. (2020) studied detachment of nanoparticles in granular media filtration.

In this paper, nitrate values in Najaf Abad aquifer in Isfahan province is determined. Sampling from 8 wells was done according to the standard sampling principles and sent to the water lab for analyzing the nitrate content. Determination of nitrate content was performed by spectrophotometric method. Then, the concentration of nitrate was plotted using ArcGIS 10 software and interlinking models.

2. Location of the study area

The study area is located in the northwest of Isfahan city and about 30 to 90 kilometers away from this city along the main road of Isfahan to Khuzestan and is located at least 35 km from the Daran city.

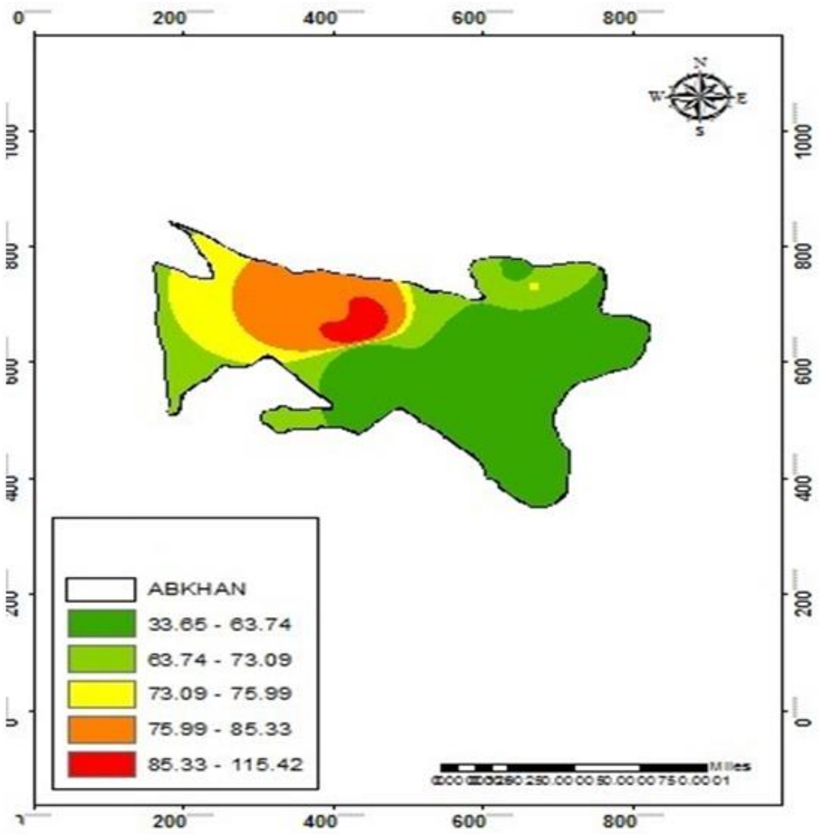

Fig. 1 Nitrat concentration zoning map

3. Methodology

Surface and subsurface studies have been carried out in Najaf-Abad study area in order to identify the hydrogeology and groundwater conditions. In surface studies , geological maps, aerial photographs and satellite imagery are used and formations, the boundaries of the mountains and plains and the boundary of the aquifer were separated. Groundwater resources including wells, springs and Qanats have been identified in two stages, identification and inventory and water resources map have been prepared. In terms of subsurface studies, it is possible to drill 8 wells explored by pumping test, five loops of these 8 wells are located in free zone, and 4 of them have pumping tests. In order to study nitrate pollution, sampling was performed from 8 wells according to National Standard Sampling Principle No. 1053. The specimens were transferred to the laboratory for preparation and analysis at a temperature of less than 4 ° C for less than 15 hours in the polyethylene containers. To test nitrate in water, Standard No. 4500 was used for the 20th edition of the standard method book (12). Then, how the nitrate concentration changes, using the ArcGIS 10 software, was drawn up and compared with the 2008 World Health Organization standards.

4. Discussion

The dissolution of natural sediments containing nitrate in water, plant decomposition, livestock activities, waste, urban sewage, nitrate fertilizers and industrial activities, including sources of nitrite and nitrate entering groundwater. Nitrate is the last step in the oxidation of nitrogen compounds, which is the cause of methemoglobulinemia in infants., and the probable formation of nitrosamine carcinogenic compounds as one of the chemical indices of water pollution in sewage is worth considering. The effects of using nitrogen fertilizers are usually released in the form of ammonium cation and nitrogen and nitrite anions release in the environment, due to its high mobility and lack of absorption on the surfaces of colloids, it can be washed quickly and into surface water and underground water (16). The World Health Organization has identified a maximum nitrate standard of 50 mg / l and introduced a reverse osmosis method as one of the most suitable methods for the treatment of contaminated water. According to the World Health Organization and the latest national standard of Iran, the maximum permissible nitrate ion in drinking water is 50 mg / l in nitrate. The concentration of nitrate in groundwater in this aquifer is approximately ½ permissible drinking water. The highest concentration of nitrate was observed at station number 7 with a concentration of 115.44 and station No. 3 with a concentration of 80.94 mg / l, respectively. The lowest nitrate concentration was measured at station 1 at a concentration of 33.65 mg / l. The nitrate concentration map shows that the highest nitrate levels are located in the north and northwest of the region and this area has a relatively high vulnerability (Table.1).

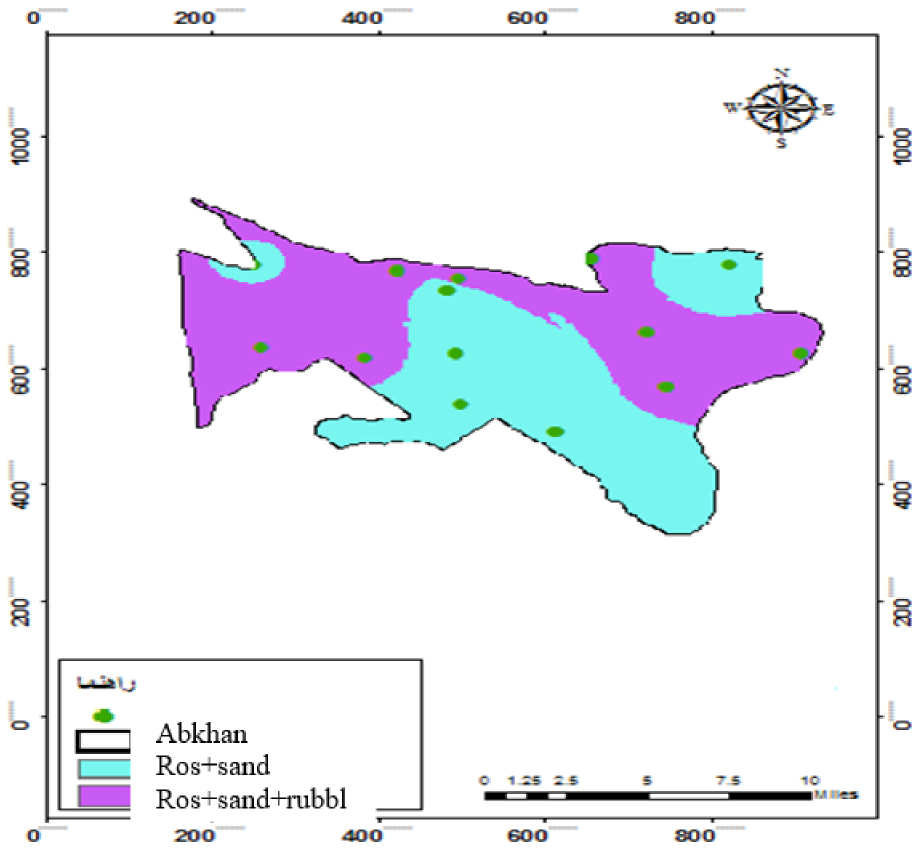

Fig. 2 Unsaturated map

Table 1 Nitrate concentration at the studied stations in Najaf Abad Aquifer

Nitrat concentration	Station No.
33.65	1
60.26	2
80.94	3
74.29	4
49.58	5
50.32	6
115.44	7
63.96	8

Table 2 Unsaturated materials

Unsaturated mediums	
Level	Material
1	Locking layer
3	Silt / Clay
3	Shale
6	Limestone
6	Sandstone
4	Ignition / Transform
8	Sand
9	Basalt
10	Karstic limestone

According to the zoning map, the highest concentration of nitrate is in the north and north-west of the region and this range has a relatively high vulnerability (Fig.1).

The unsaturated map and the level of it in the case study of this paper are presented in Fig. 2 and Table 2. It is concluded that the level of unsaturated mediums is respectively as Table 2.

5. Conclusion

Based on the experiments carried out in some of the samples high concentration of standards was recorded. According to the zoning map, the highest concentration of nitrate is in the north and north-west of the region and this range was a relatively high vulnerability. Considering the importance of nitrate pollution as one of the most important environmental problems and also the value of groundwater resources, especially in arid and semi-arid regions, it was recommended that the nitrate concentration in groundwater of this region be continuously and throughout the year.

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