GROUND WATER POLLUTION IN HOCHIMINH CITY AND IT'S PREVENTION - CASE STUDY

Tran Van Xuan
Faculty of Geology & Petroleum, HoChiMinh City University of Technology, VNU-HCMC

ABSTRACT

The presentation aims to identify area with a high need for protection to ground water. The basic components of the presentation are vulnerability assessment, contaminant source characterization and assignment of a protection proposal. The most vulnerability parts of the study area proved to be an area with a shallow ground water table coupled with corrupted well becomes a channel which conducts the polluted surface waters to the reserve and deep excavation for waste burying or from underground storage tanks. In the contaminant sources characterization, the type of contaminant, its relative concentration, mode of deposition, duration of contaminant load and possibility for remediation were considered. The sources characterized as emitting a high potential contamination load were concentrated in industrial parks and communities . The main contaminant sources were natural contamination, garbage, chemical and waste industries, sewage water outlets. A relative protection idea of ground water was proposed, based on classification of available quantities, quality, sensitivity to changes in ground water quantity and quality.

INTRODUCTION

The specter of ground water contamination looms over industrialized, suburban, and rural areas. The sources of ground water contamination are many and the contaminate numerous. Common industrial solvents have been found in widespread areas, will all indications being there are multiple sources. Suburban areas have ground water with high levels of nitrates due to the use of lawn fertilizes as well as septic tank discharges. Agricultural areas have not only high levels of fertilizers found in ground water, but specialized synthetic organic agricultural chemicals as well. Improperly constructed water well. Landfills in urban and rural areas are known sources of contamination. If there is a single source, then the contamination may be localized. If there are multiple resources, or if the contamination is a result of widespread land use practices, then the contamination may cover a large area.

Presently, in HoChiMinh City alone, there are hundreds thousand wells supplying about 300,000 cubic meters of water per day. The wells are owned by public sector, industries, institutions, individuals ... Demand for reliable adequate ground water has continued to increase over the years, a situation that has increased well density to a level that threatens to cause ground water depletion. This is made worse by at times some large users like industries being forced to rely wholly on ground water resulting on over-abstraction with likehood of damage to the aquifer.

The true ground water situation in HoChiMinh city area just be realized when a process of establishing adequate registration and monitoring system be completed which will involve analyzing the controlling parameters.

From a long term perspective it would be justified to protect all ground water at an equal and high level in order to ensure the future existence of safe, clean resource.

A more reasonable approach to ground water protection therefore would be to concentrate protection efforts on the most vulnerable and valuable aquifers or parts of aquifers , or to direct actions to where potentially contaminating sources are located.

Ground water contamination source

The major threats to ground water quality from all contaminant source are: (1) industrial waster water impoundment, (2) septic tank system (3) sanitary landfills, chemical landfills, (4) corrupted water well. The presence of any these sources can have a pronounced impact on ground water quality. Until recently, about 80 percent of hazardous wastes were being disposed of improperly in landfills or lagoons and they will present along-term threat to ground water quality.

Other obvious threats to ground water quality come from variety of sources. For example, abandoned wells can be a severe problem if poor-quality water enters aquifer having good-quality water via uncemented well bores, this problem is especially serious in agricultural areas, where animal waste, pesticides, and herbicides can easily enter the ground water system through open well bores.

Leaking gasoline storage at automotive service centers, most of which have been installed in a last 35 years, are a serious local problem in an increasing number of communities. This type of is especially detrimental because drinking water becomes unpalatable when it contains extremely low concentration of petroleum products.

These substances are extremely dangerous to humans for anywhere from 30 to 500 000 years. Yet, while the volume of these wastes has risen dramatically, no safe disposal sites have been identified or built.

Monitoring contaminant movement (transport)

In many instances of ground water contamination, the ability to predict how the contaminant plume will behave in the future can only be done on the basis of expensive drilling and sampling programs. Many scientists interested in the movement of the contaminants in the subsurface believe, however, that it will soon be possible to use mathematical modeling techniques to estimate the spread of a contaminant and its strength at any point in the plume.

The task of ground water protection

Contamination of ground water is more serious than surface water pollution because it is more difficult to detect in a timely manner, moves more slowly, and requires special expertise to predict the part and the rate of contaminant movement. In addition, the complex geochemical reactions taking place in the subsurface between myriad contaminants and earth materials are not well understood, and thus the ability to predict the concentration of a contaminant at any point is limited. The drilling contractor can take an active role in early detection of contaminant problems by being aware of well-known pollution sources and the various chemical and biological indicators that may indicate that contamination is occurring.

Ideally, contamination should be prevented from occurring. Successful prevention means that potential contaminants must be controlled so they cannot react with the ground water system. Land-use planning is a major form of prevention in which producers of hazardous wastes are kept away from areas ground water resources so that, in the event of an accident spill, little damage will occur. when potential producers of contaminants are discovered in a community or are allowed to build new facilities, action should be undertaken to develop monitoring networks that will identify ineffective disposal that could affect ground water quality. Vadose-zone sampling equipment should be placed to waste sites so contaminants can be detected as soon as possible – preferable before they enter the local ground water system. monitoring wells should be installed at appropriate places around the waste site to detect contaminant reaching the ground water system. Once a contaminant reaches the ground water, hydrogeologists should be consulted to determine the direction and rate of plume movement.

After a contaminant or several contaminants are found in ground water, a decision must be made on whether to rehabilitate the aquifer or find alternative ground water resource. In some cases, no remedial methods may be undertaken because the real extent of the contaminant is limited or the concentration of the contaminant is below health-effect standards. Occasionally, indirect remedial methods may be most suitable; for example, if a new water supply is available, the contaminated one can be abandoned. In directed remedial methods, the soil and ground water are treated to eliminate the contamination, or the source is removed and the ground water allowed recover naturally through time. In many instances, however, the renovation cost may exceed the community's ability to pay for it.

In the past, the projected costs for restoration were usually sufficient to spur the search for each water resource because new or deeper wells could be constructed at less cost than an aquifer cleanup. When new water resources are not available, however, the costs for restoration become secondary. Fortunately, some techniques used in construction and dewatering practice have been combined with new chemical treatment methods to not only contain the spread of contamination but also to begin the restoration of aquifer.

Aquifer restoration

Once contamination of a ground water supply has occurred, some actions must be taken to (1) find and eliminate the source, (2) contain the contaminants in the area already affected, and (3) restore the quality of the water aquifer, (4) Artificial recharge. Because ground water may be only fresh-water resource in many areas, restoration of the aquifer may be of the highest priority regardless of the costs involved. Protection and restoration of ground water resources must be a major concern for drilling contractors, and they should become familiar with the options available to handle contamination problems. Not only can drillers advise communities on how to solve their ground water contamination problems. They may also become involved in the process itself.

All aquifer restoration projects have some general similarities. They are costly to perform, are time consuming to plan and implement, may be only partially effective, and litigation surrounding the contamination may prevent a full disclosure of the facts.

Containment of the contaminant is the first step in aquifer restoration. Resent research has show that virtually all landfill leak. Even if various types of plastic liners or clay layers have been used retain the leachate. Capping of abandoned landfill sites with bentonite or other low-permeability material prevent rainwater from entering the site, thus eliminating the formation of leachates.

A combined method of containment and abatement is one away to effect aquifer restoration. Containment usually focuses on some hydraulic means of preventing the spread of the contaminant- either through withdrawal of contaminated water or the injection of clean water to create a pressure ridge. Withdrawal of ground water can reverse the local ground water gradient, thereby preventing the advance of the contaminant front. the water removed is usually treated before use or is discharged to the surface-water body, where dilution takes place. Contaminant plumes can also be contained by injecting large volumes of water to create a local high in the potentio-metric surface.

Slurry walls can also be used to isolate areas of contaminated groundwater. Slurry walls consist of bentonite, water, and backfill material placed in deep trenches .The mixture of soil material and hydrated bentonite can be placed as 100 ft (30.5 m). This method is particularly successful if the slurry walls can be tied into an underlying impermeable formation. Rainwater percolating into the area isolated by the slurry walls is removed by wells to keep the contaminated water from overtopping the walls. This water can be treated and then reinjected down gradient. Steel sheetpiling can also be used to construct cut-off walls to contain ground water contamination.

Ordinarily, a slurry wall will last 20 to 40 years or even longer. However, the service life of the slurry wall is greatly affected by the type of chemicals in the ground water. Organic chemicals, for example, can cause a great increase in the hydraulic conductivity of a slurry wall in only a few years.

Some wastes are so dangerous and long lasting that the only effective way to prevent long-term ground water contamination is to excavate the mineral, treat it, and replace it or to simply haul it away to a safe disposal site. Where either of these options is not feasible, the wastes are sometime completely encapsulated by impermeable materials and left permanently at the site. In other cases, chemical alternation of a contaminant in the ground can sometime be done successfully in relatively small areas.

Contaminant Sources Characterization

The Characterization of potential contamination sources was carried out in three steps: 1- identification of contamination sources; 2- screening of identified sources; and 3- Characterization of remaining sources according to their potential contamination load.

The identification of contamination sources was based on existing information available from various authories, maps. The identification was followed by a screening procedure that narrowed the number of potential sources. The screening was an organizational procedure where the contaminant sources were divided into major categories: industrial, urban, agricultural, urban landfills, and others (petrol station, oxidation ponds, cemeteries, etc...). These categories were further divided into groups depending on the type of activity carried out. The subdivision into groups was based on considerations of type of activity, handling and storage of chemicals, handling of wastes and effluents, and areas effected by disposals. Each group was assigned a priority of high , moderate, low or no priority, according to the relative amount of time to be spent on the evaluation of that particular group of sources. The contamination sources that were given high, medium, or low priority in the screening were then characterized to assess their potential contamination load to the ground water. Foster and Hirata (1988) developed a general method for assessing the risk for ground water contamination, which was further modified and applied.

CASE STUDY

General Information

The ground water is the most important source for public water supply and there are no immediate realistic alternative sources. Approximately 85% of the population lives in the BinhChanh urban and periurban area. The population and industrialized growth have let to housing shortages and spontaneous settlements. Here are a lots of new and modern industries are located in the study area. Among these are leather, shoes, textile, food processing, chemical, mechanical. Two major industrial zones can be identified. The first one is situated around South Binh Chanh - North Nha be High – way. The second is located in Le Minh Xuan, Tan Tao, VinhLoc Villages close to An Lac downtown .Beside being the main industrial zone of the HoChiMinh City, the study area is an important agricultural zone for producing industrial crops. The most important crops are sugar cane, pineapple. So a large amount of pesticides were used.

At present institution framework for ground water protection is weak and the division of responsibilities not always clear. Prior to the proposed activities, little work concerning ground protection has been carried out within the City. As the City's most development area is highly depends on ground water for water supply, HoChiMinh City municipal has a sincere interest in preserving these resources to secure future water supply.

Hydrogeological characteristics

The hydrogelogical unit classification has been based on the survey results of hydrogeological map of the HoChiMinh City on 1:50 000 scale . Groundwater in the area occurs in two form: intertitial water lying within unconsolidated , porous sediments and fissured water lying within weathering fissures and/or tectonics fractures of the basement rock . Six aquifers can be divided in the area as follows:

Intertitial aquifer in Holocene sediments (Q_{IV}).
Intertitial aquifer in Middle-Upper Pleistocene sediments (Q_{II-III})
Intertitial aquifer in Lower Pleistocene sediments (Q_{I})
Intertitial aquifer in Pliocene sediments (N_2)
Intertitial aquifer in Upper Miocene sediments (N_1^3)
Fissure aquifer in Pre-Cenozoic basement rock

The main production aquifer of area is the fourth ones: Intertitial aquifer in Pliocene sediments (N_2), that includes the specifications as follows:

The depth varies from 120 to 150 m
Hydrogen Ion Concentration: pH ≈ 4.5-5.0
Chloride : 70-250 mg/l
Total dissolved solids (TDS): 550-600 mg/l
No coliform bacteria

The water quality of upper aquifers do not satify drinking water sanitary standard by:

Human activities: cause pollution (sewage waste, garbage, corrupted water well)
Natural: poor quality (High TDS, polluted by surface water)

Pollution state and impact of ground water extraction

The pollution of ground water has been assessed for each aquifer. Among seven aquifer of the area, the Holocene and Middle-Upper Pleistocene aquifers have been subjected to strong impacts of superficial environment. The obtained data show that the Holocene aquifer has the highest grade of the pollution. Its NO_2^- content range from 0 to 60 mg/l. The deeper aquifers are less polluted. In some localities, water extracted from these aquifers has been used in beverage industry.

The investigation has been showing that almost all human activities in the survey and exploitation for groundwater have a flip side; they caused the pollution for groundwater and land subsidence.

AnLac township's inhabitants well

The water well design is checked by a consultant company and decided by authorized agent (Fig.1).

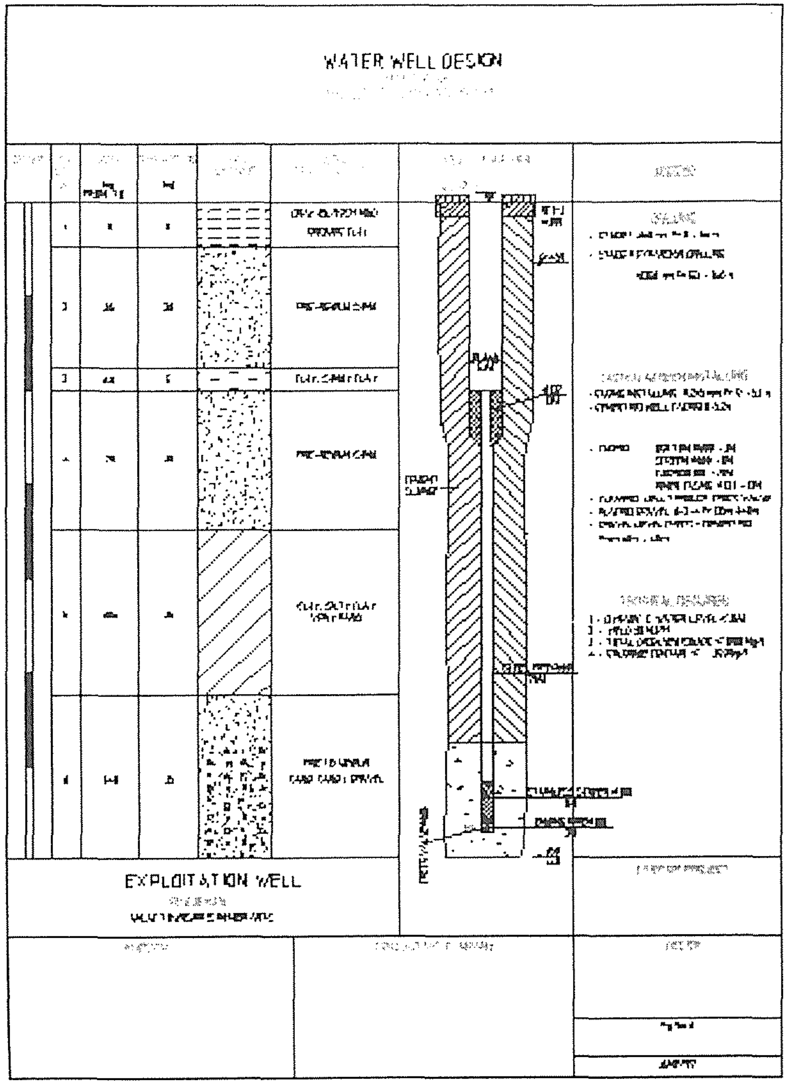
The well is started in April and completed in June 1997. For the first time, the water quality is satiate drinking water sanitary standard, excepts the iron contain and this matter is treated by a water filtration system – iron treatment. But just sixth months later ,the water quality suddenly became too bad . After some technical investigations , the water quality is apparently not enough to use for supply purpose by high TDS, Chloride contain > 500 mg/l, rotten-egg odor, presence of coliform bacteria. To resolving this situation, the operator proposed a plan such that ,the well would be caged by a casing, which diameter smaller than post casing. When a inner video sensor is run through the well (from top to bottom and vice versa) , there are reasons to cancel the proposal plan: the well is perforated at least three positions: firstly is the juncture of production and conduct casing (Φ 245 and 168),secondly is in the middle of conduct casing (Φ 168) and the last is the juncture of conduct casing and screen. Based on this result, the investor decided to abandon the corrupted well and required the operator re-constructed the new one.

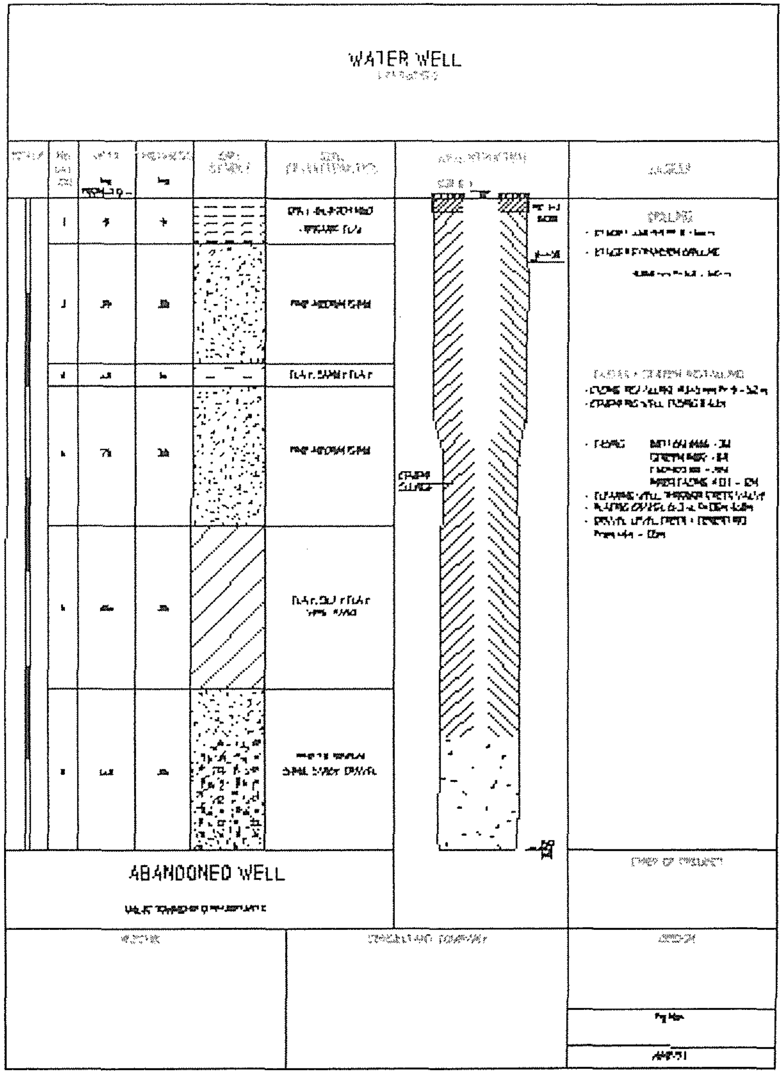
To kill the old well, the operator have to pull-up all structure of it (Fig. 4)and full-fill the hole with impermeable material (cement-betonite mixture).

Causes and sequences of well corrupted

III.1 Causes :The really causes of well corruption are just determined quite clearly after all well structure is retrieved: The first pit in the juncture of production and conduct pipe is caused by *Bio-metallic corrosion*: the conduction pipe is branch new but the production pipe is the old (discarded of petroleum industry).

The second fault in the conduct pipe (Φ 168) is result of using inadequate quality material (thickness just: 5.1 mm and roll pipe instead of thick and cast –iron pipe). The pipe is located in the high TDS formations which increase the electrical conductivity greats enough to cause electrolytic corrosion as well as the presence of chlorides and hydrogen sulfide corrode the pipe rapidly. This is the seriousness cause to make the well broken: the areas of pits reach to 100 mm in width and 400-500 mm in length , the remain of the pipe is as thick as the thickness of a paper.


WATER WELL DESIGN
EXPLOITATION WELL


WATER WELL
ABANDONED WELL

The last reason of well corrosion (in the juncture of conduct pipe and screen) is like the first (caused by *Bio-metallic corrosion)* : the screen is made of two difference metals , the outer section is stainless steel when the inner is steel cage which to restrain the crush force of the overburden pressure and kicks may appear during development procedure.

III.2 Sequences:

The corrupted well becomes a channel which conducts the polluted surface waters to the reserve through intake portion.

The undesirable ground water from upper aquifers invade to the main formation by the hollow casings and pollute the ground water environment.

CONCLUSION

Hydrogeological investigations in the area are still in the preliminary stage. The ground water exploitation and utilization are still very limited. Therefore, in the coming years it is necessary to carry out detailed investigation and to plain rational groundwater exploitation and utilization, together with appropriate management and protection of this valuable resource in the main following directions:

To hasten the regional hydrogeological survey on large scale for serving the socio-economic development of area. This survey should cover all the area, serving the more extract calculation of the groundwater reserves.

To promote groundwater prospecting and exploitation based on specific demand in order to obtain the highest economic efficiency, beside investigations for domestic and industrial water supply, attention should be paid also to the investigation for each demand, such as irrigation, land reclamation, aquaculture, etc.

The problem of ground water management and protection is an urgent task, because the demand for water supply increases every year. Therefore it should carry out the monitoring and inspection of groundwater exploitation, implement seriously all rules and regulations on water resource protection, prevent the impacts causing the risks of pollution sanitizations and depletion of the groundwater, and establish a groundwater monitoring network for the whole area.

Area that should be considered for ground water protection measures, or where more detailed studies need to be carried out.

The qualitative analysis of the methodology could be complemented with more detailed quantitative analysis. All methods can be carried out manually even through it is advised to use a geographic information system, which increases the possibility for analysis of the information. The storage of the data in a computerized database also enhances the potential to update the material whenever new information is acquired.

The characteristic of contamination sources is perhaps the most difficult and time-consuming aspect of the work, considering the large number of contaminant source and type of contaminants involved.

REFERENCE

i) Fletcher G. Driscoll (1989) *Ground water and well*, 2nd edn, Johnson Filtration System Inc.
ii) Vu Van Nghi, Tran Hong Phu (1998), *Nam bo Plain Ground water*, Industrial ministry.