

# **Technical aspect relating to salt groundwater intrusion problem in coastal provinces in IGPVN project**

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## **ABSTRACT**

This article presents the technical work related to the research, forecasting, assessing salt groundwater intrusion in aquifers through operating monitoring networks in coastal provinces, Nam Dinh, Quang Ngai and Soc Trang in IGPVN project. The monitoring networks were designed in accordance with geological, hydrogeological features and groundwater extraction status in each province to monitor the variation in the quality and quantity of groundwater over time. The salt groundwater intrusion in these provinces were monitored by CTD-Diver that can measure electrical conductivity (EC) installed in monitoring wells located nearby salty boundaries of aquifers. The increase or decrease of EC values in these monitoring wells allow us to access about dynamic and movement speed of salty boundaries over time. The sampling task in monitoring wells were performed two times a year to identify changes in groundwater quality, in addition  $C_{14}$  and isotopic samples were taken also to determine the age of groundwater and relationship between groundwater and surface water. Initial monitoring results had reflected the relationship between groundwater and surface water, the influence of factors such as rainfall, groundwater extraction on the dynamic of groundwater in general and the movement of salty boundaries in particular.

## **INTRODUCTION**

The recent growth of both population and economy in Viet Nam is based on the extensive exploitation of available water resources. Since surface water is vulnerable and increasingly affected by climate change, untreated sewage water and industrial waste water, freshwater aquifers will become the major resource for the future water supply of Viet Nam. Sustainable management of this finite resource is essential to life, development and environment. Against this background, Improvement of Groundwater Protection is essential for social and economic development of Viet Nam and, therefore, the major objective of the IGPVN project. Initially, the activities are focused on the coastal provinces in Viet Nam. One of the topics is defined to be of major concern for Viet Nam is Groundwater sanitization by seawater intrusion that was studied by different technical activities in each province. These technical activities had been executed in building process of monitoring networks and in monitoring process, as follows:

### ***Groundwater monitoring Networks***

Nam Dinh, Quang Ngai and Soc Trang are coastal provinces in IGPVN project that were installed groundwater monitoring networks. The locations of the monitoring wells have been chosen by the IGPVN Project based on geological and hydrogeological characteristics of provinces, following the criteria listed below:

Hydrogeological: access aquifers most relevant for water supply, complement existing monitoring sites with respect to spatial heterogeneity of aquifers.

Logistical: availability of public land, accessibility by heavy vehicle (drilling, sampling, pumping test), absent groundwater extraction in vicinity.

Economical: available budget limits the density of the monitoring network.

Monitoring wells were drilled by rotary drilling method and PVC pipe/casing, the screen slot width is 0.3 mm.

The monitoring wells were equipped with Mini-Divers, Cera-Divers and CTD-Divers to measure water level automatically.

CTD-Diver is capable of measuring the electrical conductivity of the water and it is usually installed in the fresh-salt boundary of aquifer to track water quality change.

Cera-Diver is commonly used in water with TDS from 0,8 to 1 g/l.

Mini-Diver often used in fresh water wells.

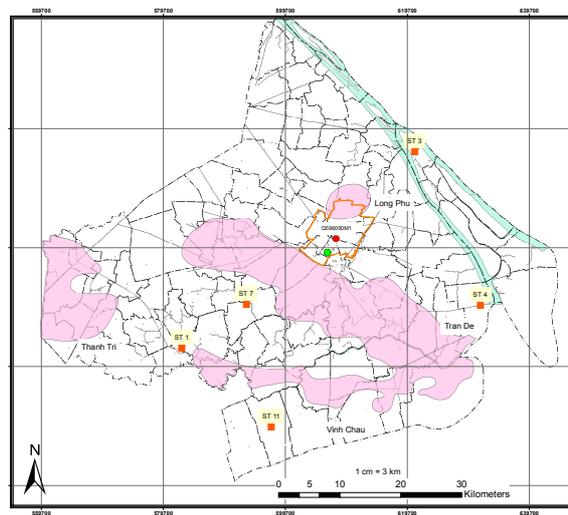
Monitoring wells and divers are usually checked every three months; the broken divers are to be replaced with the new divers right away. The salty intrusion in aquifer will be monitored by the changing of EC value that measured by CTD divers. This thing is very helpful for groundwater management in controlling groundwater quality.

### ***Well logging***

Geophysical well logging has been carried out in IGPVN monitoring wells and especially the induction well logging data provide further insight to this issue. The well logging was done before casing to determine the best position for screen, this process also determine the salinity of groundwater in formation so we can decide install the well or not. Otherwise the induction well logging has been carried out in Nam Dinh in 03/2010 after casing and the results were showed the difference of formation conductivity in depth.

### ***Other activities***

Beside the technical activities in drilling process, the groundwater sampling campaigns are also organized two times a year (March and November) to collect the groundwater samples in monitoring wells to assess the groundwater quality over time.

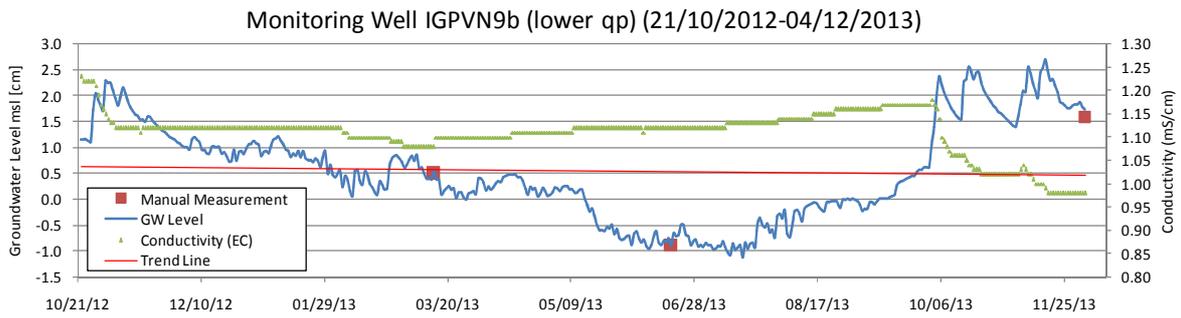


**Figure 1. Monitoring wells and fresh - salt boundary in Soc Trang province.**

## **RESULTS**

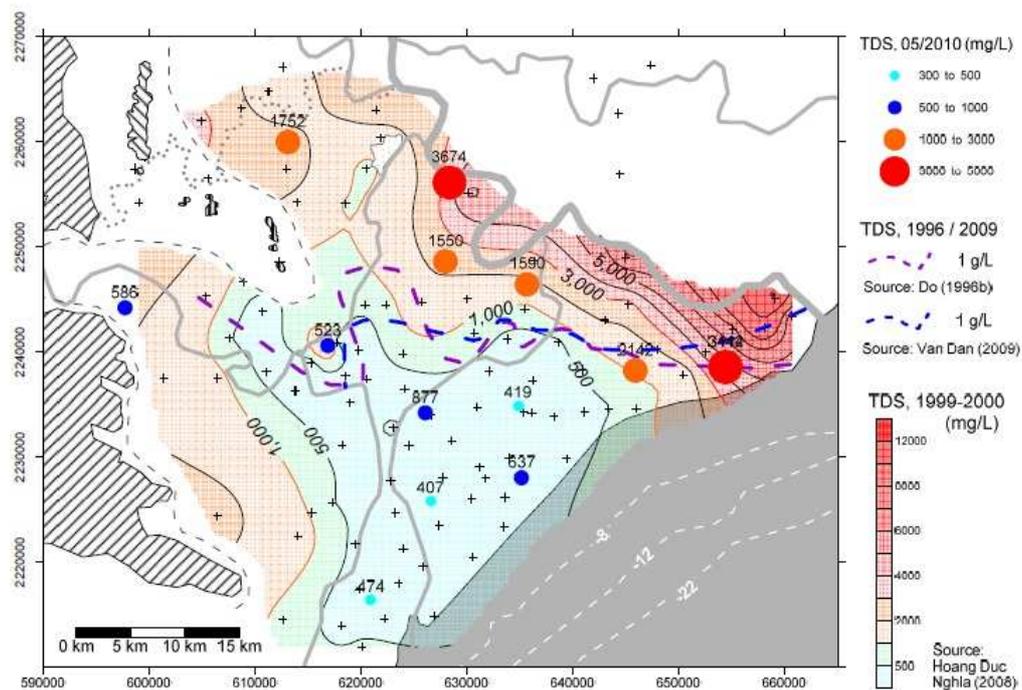
Monitoring data in province has show the changing of EC value but these changes are different in each province because of the different in groundwater dynamic. In Quang Ngai, EC value of groundwater has the inverse trend in comparison with groundwater level, when

groundwater level come down, the EC value of it come up. It is can be explained by the good relationship between groundwater and surface water or even sea water.



**Figure 2. Graph of monitoring data in monitoring well IGPVN9b (Quang Ngai province).**

In Nam Dinh province, the map about salinity groundwater was establish based on archive data from field survey of domestic household wells during rainy and dry season 1999 and 2000, collected by Hoang Duc Nghia 2008, together with data of IGPVN project from May 2010 and the salinity boundary determined in frame of the hydrogeological mapping (Do 1996b) and by geomagnetic and georadar studies in 2009 (Nguyen Van Dan et al. 2009).

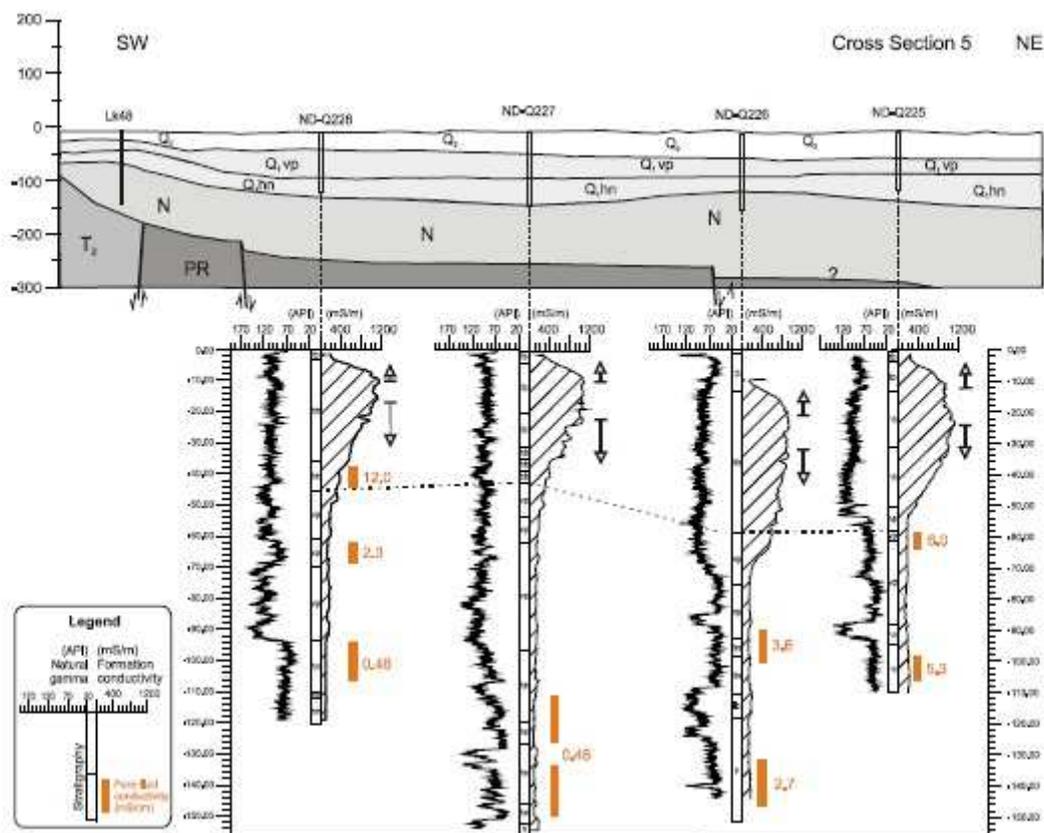


**Figure 3. Salinity distribution map (TDS) in qp pore water, based on data from IGPVN monitoring wells in May 2010 (colour symbols, TDS in mg/L).**

Indicate locally increasing salinity, such as in E boundary of the freshwater lens . Observations do not confirm brackish qp pore waters in W Nam Dinh suggested by archive data however, old as well as new data are limited in that area. The study of Nguyen Van Dan et al 2009 concludes in the mapping of the 1 g/l salinity boundary in qp aquifer based on geomagnetic and georadar studies. This boundary matches well old and new hydrochemical data in the central part, but does not in E as well as in W central area of Nam Dinh.

However, even when these geophysical methods are generally applied for shallow aquifers (< 40 m bgl), the applied modifications and the accuracy of the results are not discussed here. Generally, the transition between fresh and brackish pore waters is assumed to be quite sharp. Therefore, continuous monitoring of the transition area is necessary to quantify the movement of the salinity boundary.

Also in Nam Dinh, the results from induction logging were used to make cross sections. Figure 4 shows section crossing qp and n aquifer with fresh pore water in SW part up to brackish pore water in the NE. Four formation conductivity depth profiles are plotted for stations Q228, Q227, Q226 and Q225, derived from induction logging data. The plots are interpreted here to represent salinity profiles. Even in low saline formations changing clay content, indicated by natural gamma and confirmed by lithological description, shows only minor impact to the formation conductivity. Consequently, high conductive Holocene formations indicate the existence of high saline pore waters in the Holocene Thai Binh and Hai Hung formations. These formations mainly consist of marine fine grained sediments with high silt and clay content, occasionally intercalated with sandy layers.



**Figure 4. Cross section in Nam Dinh province showing depth profiles of natural gamma (API) and the formation conductivity (mS/m) measured by induction logging.**

The shape of the formation conductivity profiles provide further insight into vertical movement of saline pore waters when interpreted as typical diffusion profiles. Since advection may be neglected in fine grained sediments, diffusive transport is the dominant transport process driven by the specific concentration gradient. Diffusion profile with asymmetrical shape and a long slope downwards is found in Q228 and Q227 representing a high concentration gradient to the underlying pore waters. The more symmetrical shape in Q225 stands for a lower salinity gradient of the pore waters from Holocene to Pleistocene

formations. Since diffusive transport in clay formations requires a stable concentration gradient in a long term, very low saline pore water in qp (and n) unit in SW Nam Dinh already must have existed during the Holocene marine transgression time if not much earlier. Thus, downward and, in a lesser extent, upward diffusion is believed to be the main driver of salinity (Na-Cl) transport, indicated by arrows. This explains the existence of brackish aquifers not only in qh1 and qh2 but also in deeper qp and n aquifers. The fresh water aquifer in S and W Nam Dinh only exists due to the continuous side flow of fresh groundwater flushing saline waters to the East as well as coastward. Thus, increasing groundwater abstraction threatens to interrupt or even inverse the flushing process.

## **DISCUSSION AND CONCLUSIONS**

- Groundwater monitoring networks were operated quite well in three years in Nam Dinh province and nearby one year in Quang Ngai and Soc Trang provinces, monitoring data have shown the status about groundwater resource in aquifers in which include salty intrusion based on the data of CTD divers.
- The relationship between the changing of EC value and groundwater level is different in different area, it reflects the relationship between groundwater and surface water especially in shallow coastal aquifers.
- CTD divers in monitoring wells nearby salt-fresh boundary played an important role in monitoring the salty intrusion in aquifers.
- The results from induction logging is very important in groundwater exploration, at the same time these conductivity data of formations will be used to calculate the conductivity of groundwater in aquifers. The resulting pore water salinity profile has to be taken with care in the diffusion model helps to understand and quantify sanitization processes in Nam Dinh as a basis for future numerical modeling of salinity intrusion processes.

## **REFERENCES**

Frank Wagner, Dang Tran Trung, Hoang Dai Phuc and Faulk Lindenmaier. 2011. Assessment of Groundwater Resources in Nam Dinh province, Final technical report. No

Hoang Dai Phuc, Pham Thi Thu. 2013. Technical report 31, Checking monitoring wells and downloading data from Diver in Quang Ngai province.