Groundwater reserve and capacity of groundwater extraction for Ilmenite placer mining in Ninh Thuan province

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ABSTRACT:

Mining ilmenite placer develops quickly along the coastal zone in the center area, Vietnam. In Ninh Thuan province, the mines are mostly using water for the exploitation. We simulated groundwater flow with uncertain parameters in order to answer if groundwater can supply a part of water demand for the exploitation of ilmenite by using GMS software. Unfortunately, as the results of simulation, groundwater is not enough to supply for ilmenite exploitation. The authors calculated the ilmenite reserves in several communes in Ninh Thuan and water demands. Comparison of water demands and ability of groundwater supply concludes that local government should make a sustainable strategy of water use to preserve groundwater.

Keywords: *ilmenite placer, groundwater modeling*

INTRODUCTION

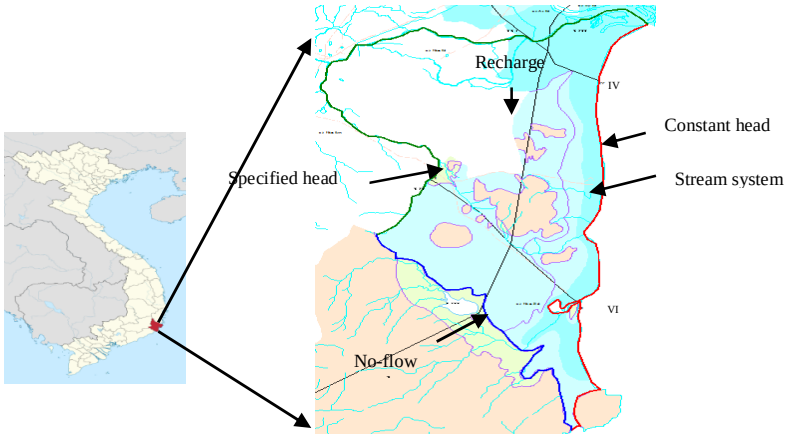


Figure 1. The study area and conceptual model

An Hai and Phuoc Hai Communes belong to Ninh Phuoc district, Phuoc Dinh belongs to Thuan Nam district are selected as the study area (Fig. 1). The total area is about 11320 ha with 41000 residents. Local people are using both groundwater and surface water for their livings and irrigation as well. These communes are in the area that the national government gave the ilmenite exploitation license to mining companies. The area is bounded by Dinh river in the north, the Lu river

and Tam Lang stream in the south, a coastal line in the east, and a mountain in the west - south.

GROUNDWATER MODELING INPUTS

Ilmenite reserves and water demand

Ilmenite placer reserves are about 17.2 million tons distributing on 3988 ha. To mine this ilmenite reserves, it needs about 2.5 billion m^3 of water. The period of ilmenite exploitation is 12 years. It means water should supply averagely about 209 million m^3/year of water. The recycling water is averagely about 40%. Besides, the groundwater demands were observed in 2010 is about 14,491,664 m^3/year.

Table 1. Groundwater demands of different activities in 2010 (m^3)

Water demand / Commune	Livings	Breeding animals	Agriculture	Industry	Total
An Hai	332,340	55,420	4,170,954	0	4,558,715
Phuoc Hai	304,372	81,672	5,984,817	0	6,370,860
Phuoc Dinh	200,371	85,256	3,276,463	0	3,562,089
Total	837,083	222,347	13,432,234	0	14,491,664

Conceptual model

Figure 1 describes the conceptual model of the study area. The meteorological data show that rainfall is annually 760 mm. It is the smallest rainfall in Vietnam while evaporation is very high; about 1,723 mm. The evaporation is much higher than the rainfall in the area. Therefore, drought is very serious problem in Ninh Thuan province. In the model, recharge was used to simulate about 40% of rainfall. The evaporation influents on groundwater level where the depth is less than 2 m. Consideration of previous data, groundwater table depth is mostly below 2 m.

The streams and rivers are the recharge sources for the aquifer at the study area. The conductance of streams depends on stream-bed material, water level fluctuation and width of stream as well. This conductance data is based on topography map and report of water balance (Nguyen, 2012).

Geological data

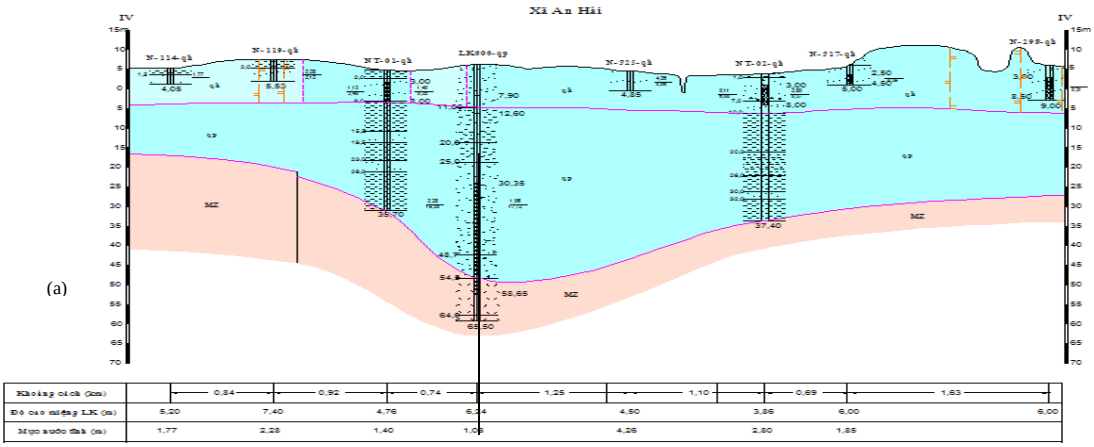
Topography and geological data are from geological map and hydrogeological map with 1:50,000 scale. Three cross-sections above (figure 2) indicate that the thickness of aquifer layer is larger from the west-south to the east-north. The section VII-VII show that the bed-rock present in the ground surface. The thickness of aquifer is very thin. It means that groundwater is very less in the centre of the area. Moreover, there is no much difference of permeability of Holocene and Pleistocene aquifers.

Therefore, the model assumes as one aquifer to simulate groundwater flow in the area.

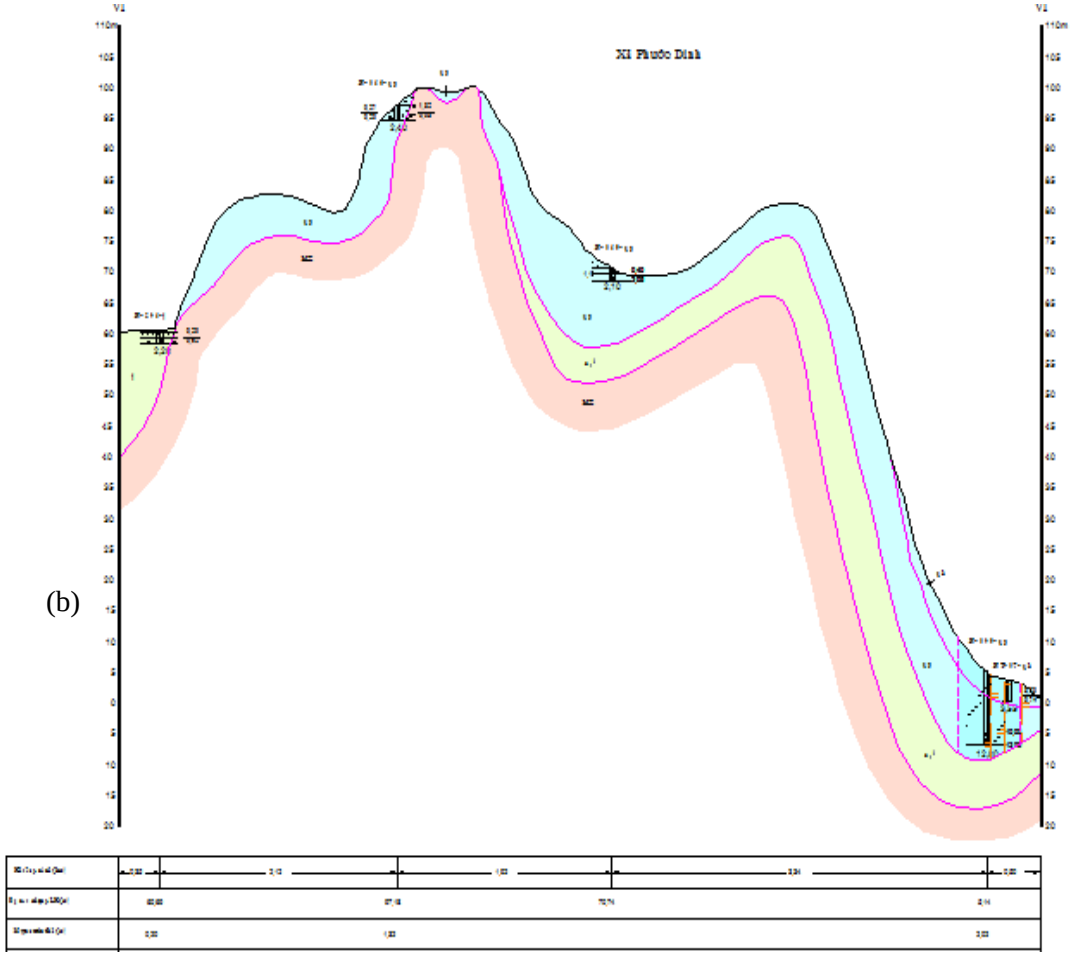
According to the pumping test in the study area (Quang Thuan – Ninh Thuan Co., 2013), the average permeability of the study area is about 20m/day for sand materials.

Study area

(a)



(b)



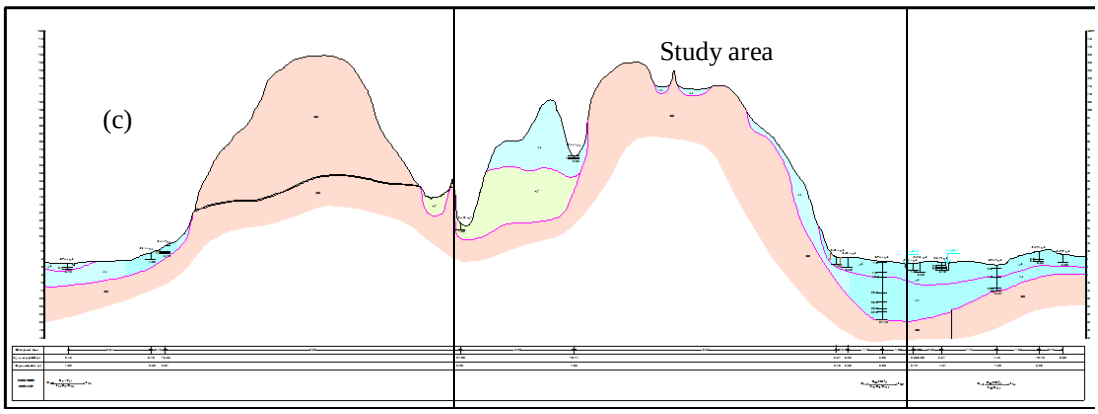


Figure 2. Hydrogeological cross-section (a- Section IV-IV, b- Section VI-VI, c- Section VII-VII, *source: DONRE of Ninh Thuan*)

Model results and Discussion

Groundwater flow was simulated in the steady – state. Unfortunately, there is no observation data of groundwater level.

Figure 3 shows the groundwater flow pattern. Groundwater flow has two main directions. The direction of groundwater flows from the west-south to the east – north and other direction is from the west-north to the east – south.

Table 2 shows water balance in the study area. Groundwater flows into the study area from the boundary is 167,536 m^3/day and flow out is 212,369 m3/day. The water discharge from streams to groundwater is about 130 m^3/day and water recharge from groundwater to the streams is about 118 m^3/day. The recharge from rainfall is about 84,529 m^3/day.

The water demand showing from the wells is 39,708 m^3/day. It is about 47% of rainfall recharge. It means we can use the rest of 53% of rainfall recharge for other purposes. In this case, we do not consider the increase of water demand for livings, breeding animals, agriculture in the future.

Ponce (2006) suggested that it should left at least 40% of recharge to protect groundwater crisis. As our estimation, water demand for such demands in next five years is about 84,932 m^3/day. It is over the rainfall recharge. Department of natural resources and Environment of Ninh Thuan Province plans to use groundwater for ilmenite exploitation. As mentioned above, water demand for ilmenite exploitation is about 573,068 m^3/day. It is very high than recharge, even though total flow input is still less than this water demand. It should not use groundwater as water supply for ilmenite exploitation.

Table 2. Water balance

Sources/sinks	Flow in (m^3/day)	Flow out (m^3/day)
Boundary	167,536	212,369
Stream	130	118
Wells	0	39,708
Recharge	84,529	0
Total	252,195	252,195

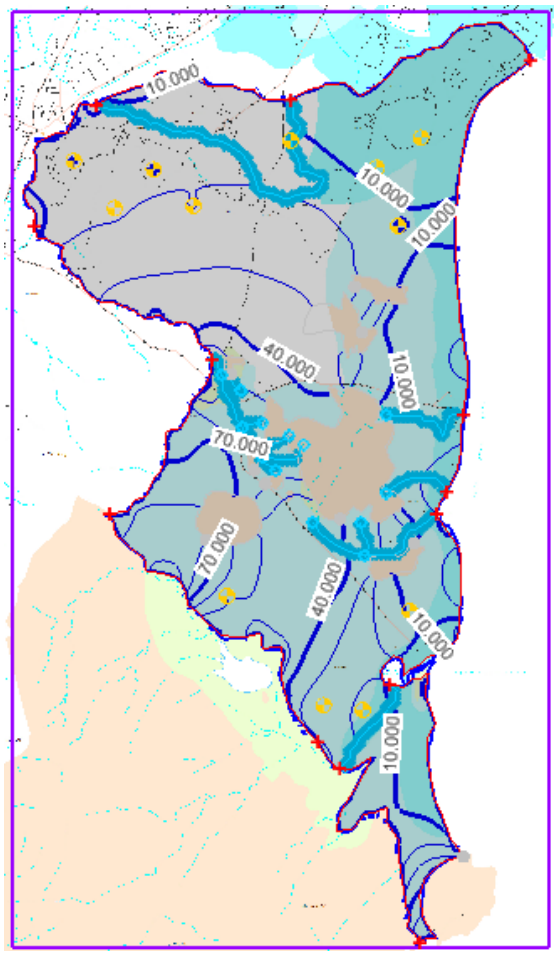


Figure 3. Groundwater flow pattern

CONCLUSION

Groundwater is limited in the study area. Recharge from rainfall is much smaller than the water demands for livings, breeding animals, agriculture in the future. For any purpose of water using, water supply for livings and other activities of local residents should be the first priority. Therefore, it is important to make planning to use groundwater and surface water reasonably for development purpose of the local area. Ilmenite reserves are good for exploitation. However, use of groundwater for the exploitation purpose should be carefully considered. The paper suggests that groundwater should not be use for this purpose in order to meet the sustainable development.

Trữ lượng nước dưới đất và khả năng sử dụng nước dưới đất phục vụ cho việc khai thác sa khoáng Ilmenite tại tỉnh Ninh Thuận

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TÓM TẮT:

Việc khai thác sa khoáng ilmenite ngày càng phát triển dọc theo bờ biển miền Trung, Việt Nam. Tại tỉnh Ninh Thuận, các mỏ hầu hết sử dụng nước để tuyển quặng. Nhóm tác giả đã mô phỏng tầng nước dưới đất tại vùng nghiên cứu với một số thông số không chắc chắn nhằm trả lời cho câu hỏi liệu nước dưới đất có khả năng khai thác để phục vụ cho nhu cầu khai thác ilmenite tại Ninh Thuận không. Phần mềm GMS được sử dụng để mô phỏng sự cân bằng nước trong vùng. Nhóm tác giả tính toán lượng nước cần dùng dựa vào trữ lượng ilmenite tại 3 xã thuộc tỉnh Ninh Thuận. Kết quả này được so sánh với khả năng cấp nước được tính toán từ mô hình. Thật không may, kết quả mô hình chỉ ra rằng, nước dưới đất không đủ để phục vụ cho việc khai thác ilmenite. Vì vậy nhóm tác giả khuyến cáo chính quyền địa phương cần lập kế hoạch sử dụng nước bền vững để bảo vệ nguồn nước trong vùng.

Từ khóa: Sa khoáng ilmenite, mô hình dòng chảy.

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