Image classification-based groundwater pollution prediction and regional economic collaborative innovation

Yan Zhang

Received: 2 June 2021 / Accepted: 1 July 2021 / Published online: 7 August 2021
© Saudi Society for Geosciences 2021

Abstract
At present, as a nonrenewable resource, water resource has become an important living condition of human society and the whole ecosystem. As an important part of the whole social water resources system, groundwater resources play a very important role in human society. Due to the scarcity of surface water resources and the aggravation of pollution, human beings began to exploit the relatively clean underground water. In China, groundwater accounts for about one third of all water resources, and is one of the important water sources for people’s living water, social production, and development. At present, many cities in China are using groundwater as industrial and domestic water. Because of the nature of groundwater, when it is polluted, it is difficult to treat and recycle, which directly affects people’s water use and social development. Therefore, we propose a groundwater pollution prediction method based on image classification. Supply chain coordination based on the analysis of the basic principles of regional economic innovation system, this paper focuses on the problems related to the supply chain system coordinated with the development of regional economic innovation. By creating a supply chain system and combining with the characteristics of regional economic development, the decentralized system can be integrated across different regions, departments and companies. In this paper, through the realization of the optimal allocation of production factors resources, to achieve the value reconstruction and create the added value of regional economy and industrial collaborative innovation, effectively promote the healthy and scientific development of China’s social economy.

Keywords Image classification · Groundwater pollution prediction · Regional economy · Collaborative innovation

Introduction
This study explored a chemical plant in District T, City C, and estimated groundwater pollution around the chemical plant in operation based on groundwater modeling (GMS) software. Using image classification methods, based on the compilation of numerous hydrogeological data in the T area, ongoing groundwater quality research, and monitoring of the groundwater environment, a reasonable assessment of the current groundwater quality in the area has been made (Adinkrah-Apiah et al. 2016). At the same time, the aquifer types and groundwater characteristics of the study area were analyzed, and the study area was generalized into a heterogeneous, anisotropic, two-dimensional steady flow groundwater model, and a hydrogeological conceptual model of the study area and groundwater was established (Al-Qadhi and Janardhana 2017). Based on the analysis of the fitting results using the measured flow field, the model can be used to represent the actual state of groundwater flow in the study area (Anbalagan and Raghuvanshi 1992). On this basis, by analyzing the pollution sources in the plant area, the highest chemical oxygen demand in the production process of the chemical plant is selected as the predicted characteristic pollution factor (Avci et al. 1999). Assuming that the chemical plant wastewater reservoir is leaking due to sewage corrosion and other reasons, and the antiseepage measures are partially invalid, the groundwater COD index of the study area is modeled and predicted, and the groundwater pollution prediction results are analyzed (Aydin and Basu 2005). With the passage of time, the halo form contaminated by COD becomes obvious, its range continues to expand and eventually stabilizes, and the maximum
pollutant concentration also tends to increase with time, and then stabilizes (Ayorinde and Mopa 2014). Based on the results of this pollution, measures to predict, control, and protect pollution sources in plant areas. The research provides a reference and theoretical basis for predicting the impact of chemical plant relocation and proposed projects on the future groundwater environment, and has practical significance (Azimian 2016). Based on the theory of industrial agglomeration, the theory of regional unbalanced development, the theory of joint development, the theory of economies of scale, and the theory of technological innovation, this article also discusses the theoretical model of the coordinated development of regional economies (Bale et al. 2011). Due to differences in resources, political environment, and innovation potential, the collaborative innovation between them has created an imbalance between the two regions (Balemwal 1991). At the same time, the current level of synergy between certain areas of China and regional economic development is very low (Barton and Choubey 1977). In order to further increase the degree of joint development of the regional and regional economies, improve the regional governance structure, optimize the layout of regional spatial resources, accelerate the process of industrial transformation and modernization in specific areas, and establish a benign interactive and coordinated development mechanism for a certain area and the regional economy in an all-round way (Basahel and Mitri 2017).

Materials and methods

Overview of the study area

The study area is located in the northeast of the T area of city C. It is adjacent to District H and T in the west, District D in the south, County A in Province S in the west, and County P in Province S in the north, facing S Province J District, with an elevation of 300–450 meters in the shallow hilly area of the basin. Zone T belongs to the Longnüsi semiannular structure system, with simple tectonic trajectories, wide and gentle anticlines and synclines, and belongs to the gentle fold belt in central Sichuan (Bell 2007).

The study area is mainly distributed in the Mesozoic Jurassic layer, the most common is the red Jurassic layer (Bieniawski 1993). According to excavations, various gneiss and metamorphic rocks are scattered along the bottom of the study area (Bieniawski 1993). These different granites and metamorphic acid effluent rocks are common under the cap rock. The music style of the middle and lower Ordovician is parallel and contradictory under the Permian (Blyth and Freiats 1984). An evaporative construction was formed in the early and middle Triassic, and a gray cladding construction was formed in the late Triassic, and the Jurassic red cladding construction was formed (Bosellini et al. 2001). The cap layer folds are mainly short-axis anticlines or nose-like structures and semiannular structures, which can be divided into two grade IV structural units (Dinku 2005).

Groundwater pollution prediction model

The single factor index evaluation method is currently the most popular method for groundwater evaluation. It calculates and analyzes the pollution index of various pollution factors in the evaluation area, and evaluates the entire area based on the pollution analysis results of each pollution factor. The specific calculation process is as follows:

For a specific pollution factor i, the formula for calculating the pollution index is as follows:

$$P_i = \frac{C_i}{S_i}$$

(1)

The calculation formula of groundwater pH pollution index is as follows:

$$P_i = \begin{cases} \frac{7.0 - C_i}{7.0 - C_{id}} (pH \leq 7) \\ \frac{C_i - 7.0}{C_{id} - 7.0} (pH > 7) \end{cases}$$

(2)
Since groundwater flow obeys the law of conservation of mass, the following permeability continuity Eq. (4) can be obtained, namely, the water balance equation:

\[-\frac{\partial}{\partial t} \rho \nabla \Delta x \Delta y \Delta z = \frac{\partial}{\partial x} \left( \rho \frac{\partial v_x}{\partial x} \right) + \frac{\partial}{\partial y} \left( \rho \frac{\partial v_y}{\partial y} \right) + \frac{\partial}{\partial z} \left( \rho \frac{\partial v_z}{\partial z} \right) \]  

\[\Delta x \Delta y \Delta z \approx \frac{\partial}{\partial t} \rho \nabla \Delta x \Delta y \Delta z \]  

(4)

Summarizing the hydraulic characteristics of the study area, the following differential equations of heterogeneous, anisotropic, two-dimensional fixed groundwater system can be listed (5):

\[\begin{align*}
\frac{\partial}{\partial x} \left( k_x \frac{\partial h}{\partial x} \right) &+ \frac{\partial}{\partial y} \left( k_y \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left( k_z \frac{\partial h}{\partial z} \right) + \omega = 0 \\
k_x \frac{\partial h}{\partial x} &+ k_y \frac{\partial h}{\partial y} + k_z \frac{\partial h}{\partial z} = H \\
\frac{(h_x - h)}{\sigma} &- k_x \frac{\partial h}{\partial x} = 0 
\end{align*}\]  

(5)

Data processing

China divides groundwater quality assessment standards into five categories. The evaluation standard is based on the specific conditions of the study area and the “Groundwater Quality Standard” (GB/T14848–2017) organized and revised by the Ministry of Land and Resources of China in 2017. This time, the Type III standard in the evaluation standard is selected (see Table 1).

According to the single factor index method, calculate the maximum value of each monitoring index at each monitoring point, and analyze the water quality compliance assessment. The statistical results are listed in Table 2.

According to Table 2, in this area, only the iron content in the groundwater in well #1 exceeded the standard, the manganese content in the groundwater in wells #1, #2, and #4 exceeded the standard, and wells #2, #3, and #4. The underground ammonia nitrogen exceeds the standard value. All other indicators are in line with Class III indicators of groundwater quality standards. According to the inspection by Chongqing Yubei Experimental Testing Center, the quality of groundwater in Tongnan County is mainly composed of iron, manganese, microorganisms, and turbidity. Iron and manganese are common physical and chemical indicators. In the unique geological environment of this area, excessive ammonia nitrogen in the local native geological environment may cause ammonia nitrogen to exceed the standard. The representative factors identified in this study do not include ammonia nitrogen. In this study, the ammonia nitrogen in wells #2, #3, and #4 exceeded the standard and did not affect the feasibility of the groundwater environment.

Results

Groundwater quality balance calculation results

According to weather data in the area, the average annual rainfall is 1,013.4 mm. Due to the small modeling range, it can be considered that the precipitation in the study area is usually evenly distributed, but this time the uneven distribution of precipitation due to topography and landforms is not considered. The rainfall in the study area is based on the average level, and the annual rainfall is 1013.4 mm.

Formula (4) is used to calculate the increase in atmospheric precipitation in the study area. The inside and outside of the factory are 0 m3/d and 1459.55 m3/d respectively. The hydraulic conductivity of the study area partition 1 is 1.76 m/d, the
water gradient is 0.007, the horizontal recharge length is 2700 m, and the average thickness of the aquifer is 40 m. According to Eq. (5), the recharge of the study area is 1300.56 m$^3$/d, observing the flow of the Fukang River, it can be concluded that the flow into the Fujian River is about 2798 m$^3$/d, and the final results of the groundwater balance calculation in the study area are shown in Table 3.

Model identification is a very important step in numerical simulation. Repeated adjustment of parameters during the recognition process will seriously affect the final fitting result. Usually, the experimental estimation correction technology is used to indirectly determine the model parameters and continuously execute the calculation program to obtain the predicted stable groundwater flow field and actually study the predicted flow field, and compare it with the groundwater flow field map and combine it with hydrology. As shown in Table 4, we analyze the geological characteristics of the study area in order to determine more reasonable hydrogeological parameters and create a groundwater flow model that is more consistent with the actual situation.

Based on the current hydrogeological data of the study area, the groundwater runoff field in the study area in December 2019 will be selected as the initial runoff field. The initial conditions are assigned to the simulation software GMS, and finally an approximate figure of the flow field predicted and measured through the simulation is obtained (Fig. 1).

Figure 1 is a fitting diagram of the predicted and measured flow fields for this simulation. According to the figure, the yellow line represents the initial flow field in the study area measured in December 2019, and the red line represents the final predicted flow field. The fitting result shows that the yellow line matches the red line, the predicted flow field matches the actual flow field, and the accuracy of the fitting mainly reflects the actual groundwater in the study area. Therefore, the simulation results can be applied to the transport model of pollutants in the model area.

### Analysis of groundwater pollution sources

According to the requirements of “Technical Guidelines for Environmental Impact Assessment-Groundwater Environment” (HJ610–2016), the selection of typical pollutants for construction projects should include:

1. Pollutant discharge under normal conditions of the proposed project;
2. Special attention should be paid to persistent organic pollutants that are difficult to degrade, easy to

| Monitoring items          | #1          | Quality index | #2          | Quality index | #3          | Quality index | #4          | Quality index |
|---------------------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|
| pH (dimensionless)        | 7.28        | 0.19          | 7.05        | 0.03          | 7.29        | 0.19          | 7.32        | 0.21          |
| Total dissolved solids    | 381.32      | 0.38          | 504.96      | 0.50          | 422.72      | 0.42          | 320.33      | 0.32          |
| total hardness            | 324.52      | 0.72          | 419.50      | 0.93          | 303.41      | 0.67          | 258.56      | 0.57          |
| Sulfate                   | 27.85       | 0.11          | 5.06        | 0.02          | 12.66       | 0.05          | 5.06        | 0.12          |
| Chloride                  | 13.98       | 0.06          | 66.39       | 0.27          | 13.98       | 0.06          | 17.47       | 0.07          |
| Ammonia                   | 0.12        | 0.58          | 0.64        | 3.21          | 0.22        | 1.09          | 0.64        | 3.21          |
| Nitrate Nitrogen          | 0.56        | 0.03          | 3.22        | 0.16          | 1.41        | 0.07          | 0.61        | 0.03          |
| Fluoride                  | 0.39        | 0.39          | 0.22        | 0.22          | 0.22        | 0.22          | 0.23        | 0.23          |
| Lead                      | ND          | /             | ND          | /             | ND          | /             | ND          | /             |
| Cadmium                   | ND          | /             | ND          | /             | ND          | /             | ND          | /             |
| Copper                    | ND          | /             | ND          | /             | ND          | /             | ND          | /             |
| Zinc                      | ND          | /             | ND          | /             | ND          | /             | ND          | /             |

### Table 3 Table of groundwater balance calculation results

| Supplies                  | Replenishment (m$^3$/d) | Excretion | Replenishment (m$^3$/d) |
|---------------------------|-------------------------|-----------|-------------------------|
| Lateral inflow            | 1330.58                 | River excretion | 2798.03 |
| Rainfall infiltration replenishment | 1495.54             | Evaporation | - |
| Total                     | 2826.12                 | Total     | 2798.03                 |
bioaccumulate, and are exposed for a long time, and are harmful to humans and organisms;

(3) Pollutants are controlled by the state or local;

(4) Ordinary products that reflect the characteristics of groundwater circulation and the type of water quality or products that exceed the standard. Since the proposed project is a chemical production project, representative pollutants should be selected according to the requirements of the guidelines, and the most representative typical pollutants should be selected.

Due to the influence of the hydrodynamic dispersion effect, it is impossible to accurately measure the current state indoors or in the field. This research is based on previous findings and similar research experience to the model (see Fig. 2), and the empirical value of dispersion is 5m.

**Groundwater environmental impact prediction**

Based on the prediction scenario of groundwater pollution in the study area, the groundwater flow model generated by GMS uses the MT3D module to generate a transition model of the COD pollution factor in the study area, and the COD pollution factor is 50d. Table 5 shows the predictions and final migration results of the 300d, 1000d, 2000d, and 3650d simulations.

---

| Partition | Permeability coefficient K (m/d) | Water supply (dimensionless) |
|-----------|----------------------------------|-------------------------------|
| Level     | Vertical                         |                               |
| 1         | 1.81                             | 0.79                          | 0.10 |
| 2         | 1.70                             | 0.77                          | 0.16 |
| 3         | 1.66                             | 0.75                          | 0.14 |

---

Figure 3 shows the result of 50D pollution transport; Figure 4 shows the results of 300D pollution transport; Figure 5 shows the results of 1000D pollution transport; Figure 6 shows the results of 2000D pollution transport; Figure 7 shows the results of the 3650D contaminated transport;

Figures 3 to 7 respectively show the predicted results of COD leakage from the bottom of the pond to the groundwater environment of the study area under normal operating conditions of the plant area after 50, 300, 1000, 2000, and 3650 days after a major leak occurred at the bottom of the sewage sedimentation tank of the proposed plant area. Compare 50d, 300d, 1000d, 2000d, 3650d (3 mg/L or higher in the "Groundwater Quality Standards" (GB/T14848–2017)) in the predicted result map with the predicted pollution results, the chemistry of Class III groundwater. The oxygen demand is 3 mg/L or less. The COD pollution halo of the pollution factor is slowly spreading to the aquifer downstream of the original factory site. After 1000 days, excess pollutants will diffuse within a radius of 400 m; after 2000 days, excess pollutants and susceptible areas will usually be widely distributed, which will have a significant impact on the research goals in the field of environmental protection.

Modeling COD pollution migration can draw the following laws: (1) As time goes by, the pollution range of COD pollution factors continues to expand and eventually stabilizes. (2) As time goes by, the maximum concentration of pollutants also increases with time, and then stabilizes and spreads downstream of the factory.

---

**Fig. 1.** Fitting diagram of groundwater flow field

**Fig. 2.** The lgaL-lgLs diagram of the 2-dimensional numerical model of porous media
Results of regional economic collaborative innovation

According to Harken, professor of physics, the structure, behavior and characteristics of subsystems will affect the interaction of the entire system. The principle is related to the development of disordered to orderly systems. In a specific area, if you observe its development process, you will usually follow the development path of “separation-diffusion-symbiosis-integration”. This is mainly expressed as follows: Initially, the development of the region should be based on the city and depend on the funds, personnel, technology, and infrastructure provided by the major cities. The improvement of infrastructure directly affects the survival rate, and even determines the survival rate. The internal links between regions are weak, and the development goal of a specific region is to develop basic leading industries and lay the foundation for regional economic growth. With the development of the region, the spreading effect of the growth pole began to appear, the economic cooperation within the region was strengthened, and the phenomenon of "backfeeding" cities began. In the third stage, the rapid development of the transportation information network will gradually reduce the inequality between regions, gradually plan cooperation from the strategic level to the spatial level, and gradually increase the degree of economic connection. However, this is a homogeneous phenomenon in the industry. In the fourth stage, the role of the market is becoming more and more obvious, the development of inter-regions is interdependent, and it has entered a stage of high integration and integration. Solving the common problems of the region requires a new driving force for coordinated development. For the regional economy, joint development effectively prevents the waste of resources due to serious industrial integration and fierce competition, reduces market transaction costs, and actively promotes the joint innovation of favorable resources with regional companies. The effect of "1+1>2" can be achieved, which is very important for achieving high-quality design. The internal mechanism of functional interaction and integration was initially formed between high-tech enterprises, specific regions and regional economies. As shown in Fig. 8.

Regional development contributes to the spatial development and evolution of cities. Its main basic driving force comes from the mutual driving forces of economic activities between regions and cities. These potential driving forces not only have a significant impact on the economic development of a specific region, but also contribute to regional economic development. China also plays an important role. As shown in Fig. 9:

Discussion

Groundwater pollution analysis

Source control measures

According to the current assessment of groundwater quality in Chapter 3 of this article, the actual groundwater monitoring indicators in the study area meet the requirements of the
groundwater standards of Category III “Groundwater Quality Standards” (GB/T14848–2017). At the site of the proposed factory, if no intrusion prevention measures are taken, wastewater leakage will occur in the wastewater treatment plant in the factory, and wastewater leakage will also occur in the production workshop and sewage treatment station. Unless some emergency protective measures are taken, the leakage of wastewater will be harmful. The groundwater resources and water quality downstream of the proposed plant will have a serious impact.

Forecasts indicate that in the early stages of wastewater leakage, the COD pollution range extends to the downstream of the proposed site. Among them, the COD pollution factor exceeds the normal level, and the farthest exposure area is the Fujiang River, which is about 800 m away from the planned construction site downstream of the factory. Some residents have not yet moved, exceeding the established pollution standards on both sides of the Fujiang River, while those who have not yet moved continue to use pressure wells to extract groundwater in the area.

Model predictions show that pollutants cause the chemical oxygen demand to exceed the plan limit, greatly exceeding the standard will seriously affect the surface water of the Fujiang River, and endanger the safety of domestic water for residents around the plant. Therefore, during the construction of the factory, strict antiinvasion work must be carried out so that the proposed project will not affect the environment of the proposed project under normal and abnormal operating conditions.

Once groundwater is contaminated, it will be difficult to recover. The main countermeasure for groundwater pollution is source control, which is to do a good job as soon as possible, strengthen measures to protect the groundwater environment, and minimize groundwater-related disasters. Source control can be achieved from the following aspects:

1. In the planning process, the proposed plan should follow the principle of “three simultaneous”. In other words, the pollution control and monitoring measures of the construction project must be designed, constructed, and put into production at the same time as the main project;
2. During the construction process, it is necessary to strengthen supervision to ensure the quality of the construction process;
3. Construction technicians must study the technical requirements and quality standards of the antisepage project, and a dedicated person shall be responsible for quality control during the construction process and draft construction records. If an abnormality occurs, it must be properly dealt with in accordance with the regulations of the relevant department, and quality control shall be carried out during the construction process. After completion, the quality inspection and project acceptance must be carried out in accordance with the regulations of the relevant country.
4. In the normal production process, it is necessary to check whether there are overflows, discharges, stains, and pollutants leakage in time. If the antisepage sealing
material is found to be aged or damaged, it needs to be repaired and replaced.

Zoning prevention and control measures

According to the prediction results and the reference table of groundwater pollution impervious area in “Technical Guidelines for Environmental Impact Assessment—Groundwater Environment” (HJ610–2016), the construction method of each production unit in the factory is based on the factory. It is divided into two categories, the main antientry zone and the simple antientry zone, and appropriate measures have been taken.

It is suitable for residential areas that prevent concrete infiltration, and the concrete antiseepage layer must meet the following requirements:

1. The strength grade of the concrete impermeable layer should not exceed C20, and the water-cement ratio should not exceed 0.5;
2. In general pollution control areas and control areas, the impermeability grade of impermeable concrete should be greater than P8, and its thickness should be greater than 100 mm;

At the same time, groundwater pollution can be reduced through the following aspects:
(1). We will establish a monitoring system to monitor the groundwater level and water quality upstream, laterally, and downstream of the project station in order to monitor groundwater quality in time. Once groundwater pollution is found, necessary protective measures shall be taken in time.

(2). Develop an environmental emergency plan, implement safety measures and prevent environmental risks, and reduce the impact on the downstream surface, groundwater, and the environment.

Analysis of collaborative innovation model of regional economy

In order to create a new type of science and technology park, the region is trying to introduce a group of independent innovation companies, these companies play an important role in promoting high-tech industrialization and new industrialization. Optimize the overall industrial structure of the region. In particular, the development of an area will inevitably lead to the relocation of the company, which will lead to changes in land use in the surrounding area. Another way to look at this situation is that the company and the government have decided to relocate their production departments only when the value of land in major cities continues to increase. Prior to the company’s relocation, space and land restrictions prevented the expansion of production in large urban areas. Since then, not only companies and governments have obtained considerable benefits, but also introduced diversified industrial roads. Update the land use practices of major cities and strengthen the interaction between specific areas and nearby cities. In addition, the production function interaction between a specific area and the local economy is also reflected in the turnover rate of the company’s products, the interaction between companies, and the interaction between different departments within the company. The development of many large enterprises in specific areas is gradually digitizing and high-tech. Their cooperation with some small companies dealing with local computer networks is approaching, and the information function between specific areas are strengthening interaction.

After years of development, parts of China have greatly improved the innovation and entrepreneurship environment and overall economic strength of the parks. At the same time, a large number of high-tech companies have been attracted, and a large number of small businesses have emerged. The independent innovation potential of the park is constantly improving. Usually, due to the interaction between a specific area and the local city, including the interaction of the company’s R&D and production departments in major cities, the R&D opportunities in a specific area are within that area. Including the interaction and collaboration between enterprises and research institutions (such as universities) in a specific area, as well as the interaction caused by the spatial dispersion of incubating companies in specific areas and regions (GSI 2004). As the city pursues the policy of “retreat two, advance three” and rebuild industrial land in the old city, more and more companies are moving to certain areas outside the city, some of which are considering the advantages of big cities. The simple transfer of the manufacturing sector to a specific area strengthens the collaboration between R&D and the company’s manufacturing sector, and promotes the functional interaction between specific areas and major cities. Another interaction of R&D functions between specific areas is caused by the spatial diffusion of incubant companies. The spatial diffusion of high-tech companies includes the spatial diffusion of material materials and the diffusion of technological diffusion. Among them, material diffusion refers to the diffusion of capital logistics to regions with potential markets, while technological diffusion refers to the introduction of advanced technological capabilities into adjacent regions, namely, specific regions and cities, to strengthen the synergy between the two.

Analysis of the impact of regional economic collaborative innovation development

The economic development and regional economic growth of the current territory are not evenly distributed in all regions. Different companies, industries, or regional associations grow unbalanced at different speeds, and leading industries or new types of companies are clustered in certain regions with different intensities. The growth center of a similar “magnetic pole” area-a growth pole, then gradually spread to other industries and companies in the region, and ultimately affects the economy of the entire region. Due to its geographical location and related specific policies, the area has a good investment and innovation environment, attracts innovative companies and talents, generates economies of scale and innovation capabilities, and rapidly promotes the development of surrounding areas through knowledge spillover effects. Promote the economic growth of the surrounding areas, and play the role of the growth pole of regional economic development.

Regional economic growth usually starts with the rapid growth of major industries and sectors, and then spreads to other sectors and enterprises in the region. The areas where these major industries and departments are concentrated are usually the driving force of economic growth in the area, which is the core factor that affects the regional economic development in a certain area (GSE 2010). According to economic theory, under certain cost conditions, the stronger the company’s agglomeration effect, the greater the production volume. The concentration of production factors in specific regions has gradually reduced the production costs of high-
tech companies. When the market price of the product is stable, the profit strategy is formulated by reducing the cost of production factors and increasing the profit of the company and the target company, choosing to expand the replication and promote growth in the entire regional economy.

**Countermeasures for collaborative innovation development of regional economy**

From the very beginning, the status and role of a certain district determined that its function is to serve as a demonstration area for the city’s "icing on the cake". The creation of different types and levels of specific regions helps to achieve optimal concentration, effective resource allocation, and a new regional economy. Growth points have contributed to the development of the local economy. Therefore, the blooming construction in urban fringe areas has led to a high degree of industrial structure convergence, leading to disorderly sprawl and urban space expansion. The convergence of the industrial structure is reflected in the desire to establish a closed production economic system, which is complete, “self-contained” and “complete in categories” regardless of its own development advantages. This is a result of diseconomies of scale and redundant construction at the microeconomic level. In fact, similar resources and similar location characteristics lead to the duplication of production patterns, the assimilation of functional locations, and the similar production structure between specific areas that have formed the production chain. The fierce competition in the neighborhood is manifested at all levels of regional development and severely restricts the development of regional economy. In this regard, it is necessary to rationally allocate space resources and political resources to benefit small and medium-sized enterprises, and to form a special inter-city division of labor system based on the characteristics and advantages of cities. For example, large cities have high levels of education and complete infrastructure. Some areas of them are usually centers for knowledge production, innovation, and transformation of results. New knowledge and new technologies are spread to smaller areas. Certain areas of small and medium-sized cities must find precise locations and use the technology and knowledge gained from large cities to successfully develop. Develop industries in specific areas of metropolises, and form a spatial coordinated development model that focuses on specific areas with points, lines, and lines.

**Conclusion**

In this research, an independent hydrogeological unit is selected as the research area, and the proposed facilities are installed in the area, and the data of the research area is systematically investigated. The hydrogeological conditions of the research area and the investigation of groundwater quality during the research process. The numerical groundwater model is used to carry out the regional distribution of groundwater flow field. When establishing the groundwater pollution prediction plan, the migration model of pollutants after groundwater leakage is simulated, and reasonable measures are proposed to protect the groundwater environment. Through the establishment of a supply chain system to achieve regional economic integration and effective integration of regional production factors, various industrial sectors, and decentralized management systems, so as to innovate and develop the local economy, and adjust all production factors. Through the organic integration of “dual employment and dual deployment” in the local economy, the conversion of new and old kinetic energy, and the organic combination of government and industrial innovation to develop the coordinated development of agriculture, industry, service industry, information industry, financial industry, international trade, and other industries, Bring huge economic and social benefits.

**Acknowledgements** Soft science research project of Shaanxi science and Technology Department (2020KRM109).

**Declarations**

**Competing interests** The authors declare no competing interests.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution, and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit [http://creativecommons.org/licenses/by/4.0/](http://creativecommons.org/licenses/by/4.0/).

**References**

Adinkrah-appiah K, Kpamma EZ, Nimo-boakye A, Asumadu KT (2016) Annual consumption of crushed stone aggregates in Ghana. J Civil Eng Archi Res 3(10):17291–1737

Al-Qadhi A, Janardhana MR (2017) Evaluation of stability of the rock slopes in Taiz City and surrounding areas evaluation of stability of the rock slopes in Taiz City and surrounding areas of Yemen using slope mass rating (SMR) system and kinematic analysis technique. Int J Eng Res Appl 7(9):36–54

Anbalagan S, Raghuvashti (1992) Rock mass stability evaluation using modified SMR approach. Proceedings of 6th National Symposium on Rock Mechanics 1992(9):258–268

Avci KM, Akgün H, Doyuran V (1999) Assessment of rock slope stability along the proposed Ankara-Pozant, autoroad in Turkey. Environ Geol 37(1-2):137–144
Aydin A, Basu A (2005) The Schmidt hammer in rock material characterization. Eng Geol 81(1):1–14
Ayorinde OO, Mopa B (2014) Preliminary field measurement of the uniaxial compressive strength of migmatite using N-type Schmidt rebound hammer. Int J Eng Sci 3(8):11–17
Azimian A (2016) A new method for improving the RQD determination of rock core in borehole. Rock Mech Rock Eng 49(4):1559–1566
Bale RB, Bayewu OO, Folorunso IO, Oloruntola MO (2011) Estimation of reserve—overburden ratio of a proposed quarry site using estimation of reserve-overburden ratio of a proposed quarry site using resistivity. Appl Sci Res 7(10):1402–1410
Balemwal A (1991) Stratigraphy and carbonate microfacies of the Hirna Mesozoic sequence. Msc Thesis, Addis Ababa Univeristy 1991(10):79
Barton N, Choubey V (1977) Shear strength of rock joints in theory and practice. Rock Mech 10:1–54
Basahel H, Mitri H (2017) Application of rock mass classification systems to rock slope stability assessment: a case study. J Rock Mech Geotech Eng 9(6):993–1009
Bell FG (2007). Engineering Geology, Second Edition, Elsevier Ltd. pp593
Bieniawski ZT (1989) Engineering rock mass classifications: a complete manual for engineers and geologists in mining, civil, and petroleum engineering. Wiley-Interscience 1989(11):250
Bieniawski ZT (1993) Classification of rock masses for engineering: the RMR system and future trends. Pennsylvania State University, University Park, PA, pp 553–573
Blyth FG, Freiats MH (1984) A geology for engineers. Elsevier, Butterworth-Heinemann London, p 349
Bosellini A, Russo A, Assefà G (2001) The Mesozoic succession of Dire Dawa, Harar Province, Ethiopia. J Afr Earth Sci 32(3):403–417
Dinku A (2005) The need for standarization of aggregates for concrete production in Ethiopian construction Industry. Inter Conf Afri Devel Arch Paper 90:1–15
Ekmecki M (1990) Impact of quarries on karst groundwater systems. Hydrogeological Processes in Karst Terrenes (Proceedings of the Antalya Symposium and Field Seminar), IAHS Publ 1990(10):5
Enatfenta M (2007) Impact assessment and restoration of quarry site in urban Environment: the case of Augusta quarry. Msc Thesis, Department of Environmental Science, Addis Ababa University 2007(3):94
Geological Survey of Ethiopia (GSE) (2010) Geology of the Harer areas (NC 38/9). Memoir 21:116
Geological Survey of Ireland (2004) Quarries and ancillary activities. guidelines for planning authorities, Department of the Environment; Heritage and Local Government, pp46.
Goodman RE (1989) Introduction to rock mechanics, 2nd edn. University of California, at Berkeley p 562
Goricki A, Button EA, Schuhel W, Pösch M, Leitner R (2005) The influence of discontinuity orientation on the behaviour of tunnels. Felsbau 23(5–6):1–11