

A QUANTITATIVE ANALYSIS OF THE TRANSACTIONS BETWEEN UNDERWATER AND SURFACE WATER IN THE HAILIUTU RIVER BASIN, ERDOS PLATEAU, CHINA.

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ABSTRACT

In severely desert environments, the interplay between surface water and groundwater is crucial for sustaining water resource management, ecological stability, and hydrological equilibrium. The quantitative analysis of groundwater-surface water interactions in the Hailiutu River Basin, Erdos Plateau, China, is presented in this work. The basin is an ecologically delicate system where the extraction of groundwater, the dynamics of surface water flow, and climate variability are all interdependent. This study uses groundwater level data, river flow records, and hydrological monitoring to look at the impact of water exchanges between river channels and aquifers on the hydrological processes in the basin. The dynamics of recharge and outflow, fluctuations throughout the year, and the effects of groundwater extraction caused by humans were studied using numerical modelling tools and water balance evaluations. Surface water availability is maintained during dry seasons by groundwater, which plays a particularly large role in river baseflow. Nevertheless, the natural balance has been disrupted due to excessive groundwater extraction, which has lowered river discharge and baseflow contributions. The research shows that surface water sustainability is impacted by the link between extraction rates and falling groundwater levels. The significance of integrated water management in semi-arid settings is shown by this quantitative analysis. The ecological integrity of the Hailiutu River Basin can only be preserved by integrated management techniques and effective restriction of groundwater consumption. In sum, this findings add to what is already known about the interplay between groundwater and surface water, and what it means for the future of water security in fragile plateau ecosystems.

Keywords: Groundwater-Surface Water Interaction, Hailiutu River Basin, Erdos Plateau, Water Resource Management.

INTRODUCTION

An essential part of the hydrological cycle that determines the distribution, sustainability, and availability of water resources is the interplay between surface water and groundwater. Due of the limited and very unpredictable precipitation, these interactions take on a greater significance in semi-arid and ecologically sensitive locations like the Erdos Plateau in northern China. At the heart of the plateau is the Hailiutu River Basin, a one-of-a-kind example of how groundwater and river water exchanges are crucial to preserving ecology and fostering

economic growth. Sustainable management now requires an awareness of these interactions due to the growing demand for water resources, particularly from groundwater extraction. Aside from being a vital source of baseflow for the river during dry seasons, groundwater in the Hailiutu River Basin also supports local agricultural and household needs. There is a two-way link that establishes the hydrological balance of the basin; when precipitation is high, surface water recharges aquifers. Nevertheless, groundwater levels have been falling and its contributions to river flow have been diminished as a result of increased groundwater extraction in response to mounting demands from population growth, agricultural irrigation, and industrial operations (Cai et al., 2020). Unchecked, these changes pose a danger to the basin's natural functions and could lead to water shortage in the future. Therefore, it is crucial for scientific knowledge and policy-making to conduct quantitative analyses of these water transactions. Researchers may evaluate recharge, discharge, and seasonal fluctuations using hydrological monitoring, modelling methodologies, and water balance evaluations. This allows them to understand the amount of human effect and natural dynamics. Data gathered from the Hailiutu River Basin, a typical semi-arid watershed in China and elsewhere, may help shape more comprehensive plans for managing water resources. In order to assess the ecological and water security consequences of groundwater extraction and river basin hydrology, this research determined the degree to which these two processes are interdependent. The results should lead to evidence-based suggestions for integrated water management that will help keep the Erdos Plateau's hydrological balance intact and its resources used sustainably (Cheng et al., 2022).

BACKGROUND OF THE STUDY

An essential part of hydrology, the interaction between surface and groundwater has a major impact on resource management, ecological stability, and the availability of water. Climate change and other human-caused stresses are putting a strain on the delicate equilibrium between these two water sources in many parts of the globe, particularly in semi-arid regions. An example of a fragile ecosystem is the Erdos Plateau in northern China, where heavy water usage and little precipitation have made it difficult to maintain ecosystems and people's way of life. An especially vulnerable watershed within this plateau, the Hailiutu River Basin is highly dependent on the interaction between river flow and groundwater. During dry seasons, when surface water imports are small, groundwater in the basin has historically been crucial for maintaining river discharge. Agriculture, community water supplies, and river ecosystems all benefit from this baseflow contribution (Duque & Rosenberry, 2022). The two systems are interdependent and dynamic; during rainy seasons, surface water adds to aquifer recharge. Groundwater extraction has escalated due to fast socio-economic growth, expansion of agricultural irrigation, and industrial water demand, disrupting this natural equilibrium. There has been a decline in river flow and groundwater levels, which threatens the region's ecosystem and its ability to secure water in the future. River drying up, soil degradation, and ecological collapse may result from unregulated groundwater extraction, according to previous research in comparable semi-arid basins. These issues are exacerbated in the Hailiutu River Basin due to its distinct hydrogeological environment and the heavy reliance of the local people on

groundwater supplies. Effective decision-making and long-term management need a quantitative comprehension of the exchanges between surface water and groundwater. This research delves into the mechanisms of recharge and outflow, seasonal fluctuations, and human influences on water exchanges by using hydrological monitoring, modelling, and water balance evaluations. Not only does it cast light on hydrological concerns in the Hailiutu River Basin, but it also offers lessons that may be applied to other semi-arid places that are going through the same thing. To preserve hydrological balance and ensure the long-term health of ecosystems and humans, it is essential to implement integrated water management techniques (Irvine et al., 2024).

PURPOSE OF THE STUDY

This research aims to examine and measure the exchanges of surface and groundwater in the Hailiutu River Basin in the Erdos Plateau in China. Given the importance of these interactions to the semi-arid region's hydrological balance, ecological stability, and water resource sustainability over the long term, it is critical to understand them. An in-depth quantitative evaluation is crucial for directing efficient water resource management in the basin in light of the growing demands placed on it by groundwater extraction, agricultural development, and climatic variability. The primary objective of this research is to determine the seasonal and reversible interactions between the two systems by analysing the groundwater's contribution to river baseflow during dry seasons and the surface water's replenishment of aquifers during rainy times. The research provided a thorough picture of the processes controlling recharge and outflow by using data from hydrological monitoring, numerical models, and water balance analysis. Along with that, it aims to measure how much groundwater pumping caused by humans upsets the natural balance and reduces river discharge. The study also aims to provide the groundwork for long-term, sustainable water management strategies in the Hailiutu River Basin. In order to help policymakers and resource managers regulate water usage, the research aims to show how groundwater extraction rates are related to falling river flows. In order to keep surface and groundwater systems interdependent and robust, it is necessary to devise methods for balancing human needs with ecological requirements. The research aims to contribute to the greater knowledge of groundwater-surface water dynamics in semi-arid environments, in addition to its local importance. When it comes to ecological fragility and water shortage, integrated management solutions are needed in watersheds like the Hailiutu River Basin and others like it throughout the globe. So, the results will help with water security in the area and may be used as a guide for future research on sustainable hydrology in sensitive habitats throughout the world.

LITERATURE REVIEW

As a consequence of its importance in water availability, ecological stability, as well as sustainable resource management, the interaction between surface water and groundwater has been extensively explored in hydrological research. Due to low precipitation and heavy

reliance on groundwater supplies, this interaction takes on added significance in semi-arid and dry areas. Research on a global scale has shown that groundwater plays a significant role in river baseflow, particularly during dry seasons, allowing rivers that would otherwise have intermittent flows to sustain permanent flows. The reversible nature of water transfers is shown by the fact that aquifers are often recharged by surface water during rainy seasons (Lewandowski et al., 2020). The significance of groundwater-surface water dynamics in sustaining ecological stability across river basins has been highlighted in research conducted in China. Similar to the problems seen in the Hailiutu River Basin, research in the North China Plain has shown that over-drilling of wells for agricultural irrigation has lowered river flows and depleted water tables. Wetland habitats and downstream water availability have been greatly affected by changing groundwater contributions in the Yellow River Basin, which has been seen in similar patterns. Findings like this highlight how semi-arid regions are especially susceptible to hydrological imbalances caused by humans. Recognised as an environmentally delicate location with limited water supplies, the Erdos Plateau is home to the Hailiutu River Basin. Groundwater is essential for maintaining river flow during lengthy dry seasons, according to previous research; nevertheless, this delicate equilibrium has been upset due to over-extraction. Anthropogenic pressures hasten groundwater depletion, decreasing ecological services and endangering long-term water security, according to research using hydrochemical tracers, isotope analysis, and hydrological modelling (Li et al., 2022).

Reduced recharge during dry years amplifies the consequences of extraction, and climatic variability worsens these impacts. The recharge-discharge interactions have been assessed using quantitative approaches on a global scale. These methods include water balance models, groundwater flow simulations, and tracer techniques. The magnitude and timing of aquifer-river transfers may be better understood with the use of these methods. Therefore, in order to comprehend local dynamics and to inform sustainable management approaches, it is crucial to apply similar techniques to the Hailiutu River Basin. Researching the interactions between groundwater and surface water is scientifically important and practically necessary, according to the current literature. Nevertheless, there is a lack of information on how to quantify water transactions in the Hailiutu River Basin in the context of climate change and human extraction since there have been few targeted research in this area. To fill that void, this research analysed these connections in depth and discuss what they mean for the management of water and natural resources on the Erdos Plateau (Li et al., 2024).

RESEARCH QUESTION

What is the effect of river discharge in Hailiutu River Basin, Erdos Plateau, China?

RESEACH METHODOLOGY

Research Design: The quantitative data analysis was conducted using SPSS version 25. In order to determine the direction and intensity of the statistical link, the researchers used a 95%

confidence interval and odds ratio. The researchers used a p-value of less than 0.05 as a statistically significant criterion. After much digging, the fundamental characteristics of the data were uncovered. Quantitative evaluation methods are often used to review data collected by surveys, questionnaires, and other ways as well as data analysed using statistical assessment software.

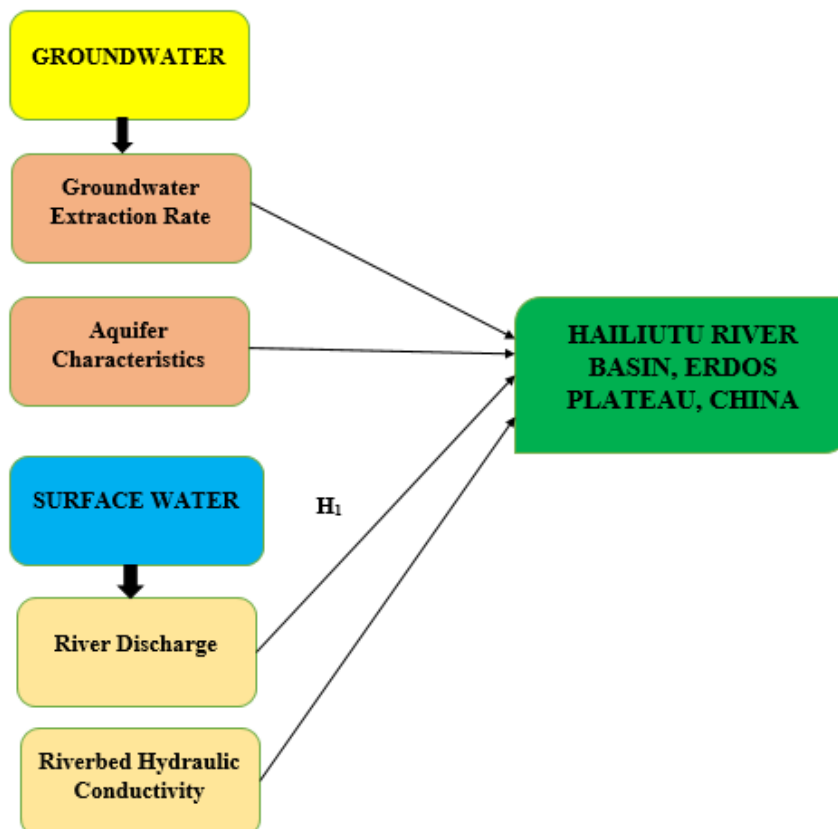
Sampling: Participants who wanted to take part in the study had to fill out surveys. After using the Rao-soft approach to determine a study population of 670 persons, 800 questionnaires were distributed. After collecting 768 responses, 68 were removed from the final sample because they were incomplete. Yielding a final sample size of 700.

Data and Measurement: The majority of the information used in the research came from a survey questionnaire. Prior to anything else, researcher needed the participant's vital demographic details. After that, researcher had participants rate the online and offline channels using a 5-point Likert scale. For this secondary data collecting, the researchers meticulously examined various resources, particularly online databases.

Statistical Software: Statistical analysis was conducted using Excel and SPSS 25.

Statistical Tools: Through the use of descriptive analysis, the key features of the data were understood. The researcher has to look at the data using ANOVA.

CONCEPTUAL FRAMEWORK



RESULT

Factor Analysis: Factor Analysis (FA) is often used to find hidden variables in observable data. Regression coefficients are often used to provide evaluations in the absence of discernible visual or diagnostic indicators. Success in financial analysis is significantly reliant on models. The goals of modelling are to identify errors, intrusions, and apparent linkages. The Kaiser-Meyer-Olkin (KMO) Test is one tool for evaluating datasets that have been generated by numerous regression analyses. The representativeness of the model and the variables in the sample are checked by them. There seems to be data duplication based on the numbers. Data is more easily comprehensible when proportions are smaller. The output of KMO is an integer from 0 to 1. A sufficient sample size is defined as a KMO value between 0.8 and 1. According to Kaiser, these are the acceptable limits: According to Kaiser, the following are the requirements for admission:

The usual range is 0.60 to 0.69, however this range is much lower at 0.050 to 0.059. A range of 0.70 to 0.79 is considered average for middle grades. Ranging from an 80 to an 89 on the quality point scale. They discover awe between 0.90 and 1.00. The Kaiser-Meyer-Olkin .943 scale. The findings of Bartlett's sphericity test are as follows: Chi-square, significance = .000, about 190 degrees of freedom this substantiates the legitimacy of the assertions made on sampling. The researchers used Bartlett's Test of Sphericity to ascertain the relevance of the correlation matrices. A Kaiser-Meyer-Olkin value of 0.943 indicates that the sample is deemed adequate. Bartlett's sphericity test yields a p-value of 0.00. A researcher may ascertain that the correlation matrix is not an identity matrix if Bartlett's sphericity test yields a significant result.

Table 1. Testing for Bartlett's Sampling Adequacy and KMO.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.943
Bartlett's Test of Sphericity	Approx. Chi-Square	4550.968
	df	190
	Sig.	.000

Moreover, the Bartlett Test of Sphericity confirmed the broad applicability of correlation matrices. The Kaiser-Meyer-Olkin metric of sample adequacy is 0.943. The researchers obtained a p-value of 0.00 via Bartlett's sphericity test. The correlation matrix did not pass Bartlett's sphericity test, indicating a significant outcome.

INDEPENDENT VARIABLE

Surface water: The main independent variable in this research is surface water because of its significant impact on the hydrological balance of the Hailiutu River Basin. Variations in

precipitation throughout the year, river flow, and runoff all make up surface water. How stable the ecosystem, how much water farmers can use for irrigation, and how quickly groundwater recharges are all affected by its availability. During the wetter months, surface water in semi-arid basins may recharge aquifers, but during the drier months, continuous flows backed by groundwater outflow are crucial. The research shows that the amount of water that moves between rivers and aquifers is determined by changes in flow volume and time, and that surface water is the independent variable that makes this determination. Since surface water is the most obvious measure of hydrological health and reflects larger climate impacts and human-caused stresses on the Erdos Plateau, it is crucial to comprehend these processes in order to practise sustainable resource management (Quan, 2023).

FACTOR

River Discharge: The main element that affects the groundwater-surface water interactions in the Hailiutu River Basin is the river discharge. It is a reflection of the equilibrium between precipitation, groundwater, and human activities that the river channel volume is measured by. The discharge plays a pivotal role in hydrological systems, as it determines the biological function, river health, and resource sustainability. Rivers' seasonal discharge patterns reveal whether they are receiving groundwater as a source or draining it from aquifers. During dry seasons, the Hailiutu River relies on baseflow contributions from groundwater, while surface flows replenish subsurface aquifers during rainy seasons. But heavy groundwater pumping lowers baseflow, which lowers total discharge and endangers river continuity. In addition to shedding light on hydrological exchanges, monitoring river flow is a useful tool for gauging environmental consequences and directing water management. Consequently, in the model of surface-groundwater interaction, discharge is a critical regulatory component (Wang et al., 2023).

DEPENDENT VARIABLE

Hailiutu River Basin, Erdos Plateau, China: Groundwater plays a crucial role in sustaining perennial river flow in the Hailiutu River Basin, which is located on the semi-arid Erdos Plateau. The groundwater-surface water ratio is crucial to the continued viability of the basin's agricultural sector, ecosystem, and human inhabitants. However, environmental risks, declining baseflow, and increased groundwater withdrawal have disrupted this balance. Basin hydrological stability is therefore directly affected by groundwater management (Zhang et al., 2023).

Relationship Between River Discharge and Hailiutu River Basin, Erdos Plateau, China: An important measure of the hydrological and ecological integrity of the Hailiutu River Basin is the river's discharge. In order to support both natural ecosystems and human activity, the semi-arid basin inside the Erdos Plateau relies significantly on the amount and variety of river flow. Even when precipitation is minimal, groundwater baseflow ensures that rivers may continue to

release water during dry seasons. As an example of how surface and subsurface water systems are interdependent, during rainy seasons, increased discharge recharges aquifers. While total river discharge has decreased, baseflow contributions have declined due to over-extraction of groundwater. The effects for biodiversity, agriculture, and the basin's ability to retain water in the long run are enormous. Sustainable water resource management in the Hailiutu River Basin relies on river flow since it reflects natural climatic fluctuations and also measures human effect (Zhang et al., 2022). On the basis of the above discussion, the researcher formulated the following hypothesis, which was analyse the relationship between River Discharge and Hailiutu River Basin, Erdos Plateau, China.

“H₀: There is no significant relationship between River Discharge and Hailiutu River Basin, Erdos Plateau, China`.”

“H₁: There is a significant relationship between River Discharge and Hailiutu River Basin, Erdos Plateau, China.”

Table 2. H1 ANOVA Test.

ANOVA					
Sum					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42515.645	259	5248.698	1612.007	.000
Within Groups	618.590	440	3.256		
Total	43134.235	699			

The outcome is substantial in this research. Statistical significance is achieved with a p-value of .000 (below the .05 alpha level), and the F value is 1612.007. This suggests that researchers might support the alternative view, “H₁: There is a significant relationship between River Discharge and Hailiutu River Basin, Erdos Plateau, China” is accepted and the null hypothesis is rejected.

DISCUSSION

This study's findings emphasise the significance of integrated hydrological management in semi-arid settings by revealing the dynamic and reciprocal link between surface water and groundwater in the Hailiutu River Basin. Groundwater ensures surface flow continuity and ecological stability by contributing significantly to river baseflow during dry times, according to the findings. Also, during rainy seasons, water from rivers helps replenish underground aquifers, showing that water flows both ways. However, this equilibrium is being jeopardised by the continued depletion of groundwater supplies, which in turn reduces river discharge due to falling water tables and reduced baseflow. According to the data, seasonality is a major factor in determining the size of these markets. An increase in reliance on groundwater outflow during drought years and an opportunity for recharging during rainy years are both exacerbated by climate variability. It becomes clear that human activity, especially irrigation for agriculture, is

the main culprit upsetting the delicate balance. Consistent with previous worldwide research conducted in semi-arid settings, these findings provide further evidence that relying too much on groundwater threatens water security in the long run. Thus, in order to maintain hydrological equilibrium on the Erdos Plateau and guarantee resilience in the Hailiutu River Basin, it is necessary to implement sustainable measures that strike a compromise between human demand and natural demands.

CONCLUSION

Located on China's environmentally delicate Erdos Plateau, the Hailiutu River Basin is the site of groundwater and surface water exchanges that this research quantifies. The results show that there is a dynamic and recursive relationship between groundwater and river discharge; during dry seasons, groundwater is crucial for river discharge, and during rainy seasons, river flows replenish aquifers. But this equilibrium has been thrown off due to overdraft from groundwater extraction, which has decreased baseflow contributions, decreased river discharge, and increased threats to environmental sustainability. The data also show how weather and seasons affect water transfers; for example, how droughts make people rely more on groundwater and how rainy seasons are great for recharging. These trends highlight the need of integrated management strategies that take into account both the water needs of humans and those of the environment. In sum, the research shows that the Hailiutu River Basin's long-term hydrological equilibrium is seriously jeopardised by unchecked groundwater extraction. To protect both surface and subterranean water systems, there must be effective regulation, sustainable extraction techniques, and integrated management of water resources. Erdos Plateau and other semi-arid places may benefit from increased resilience, safeguarded ecosystems, and water security if these issues are addressed by policymakers.

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