

Impacts of Quarry Blasting on Water Sustainability: Assessment of Social Acceptability in the Municipalities of Camalig and Guinobatan, Albay

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Abstract. Quarry blasting is perceived as a risk to groundwater sustainability by rural communities in Camalig and Guinobatan, Albay, Philippines. The Ibalong Resources and Development Corporation (IRDC) has conducted blasting operations since 2013 across three quarry sites. As many residents rely on deep wells, often shared by multiple households, concerns arise over potential groundwater depletion and contamination linked to these activities. The problem of water sustainability can be addressed through a preliminary assessment to evaluate the extent of the negative effects of blasting activities on the deep well groundwater levels near the quarry sites as perceived by the community. Survey tools and spatial analysis methods using Quantum Geographic Information System (QGIS) and GeoDa were used to assess local concerns. Results show that 51.6% of respondents observed no change or decline in their groundwater levels during blasting. Still, 38.5% perceived negative impacts, with 48.4% linking effects to blasting vibrations. Despite these concerns, spatial analyses—including z-tests, Moran's I, and regression—revealed no significant clustering or correlation between well proximity to the quarry and perceived water level changes. While there appears to be no measurable impact of blasting on groundwater levels, shared wells remain points of vulnerability. The reported presence of unusual substances like worms and sand, believed by locals to be caused by blasting, underscores the need for deeper investigation. These findings highlight the importance of considering water sustainability and equitable access in environmental management, particularly where communal groundwater sources are involved. Further research into hydrogeological variation, well construction, and seasonal patterns is essential to fully understand and safeguard water resources in quarry-affected areas.

Keywords: quarry blasting, water sustainability, social acceptance, spatial analysis

1. Introduction

Access to clean, safe, and sustainable water is a fundamental human right and a global priority under Sustainable Development Goal (SDG) 6. This goal

becomes challenging in areas where extractive industries operate near communities relying on vulnerable water sources (Kunz, 2020). In Albay, Bicol, Philippines, the Ibalong Resources Development Corporation (IRDC), a quarrying company, has drawn concern from the rural barangays of Palanog, Mauraro, Miti, Caguiba, Quibongbongan, and Bariw due to the potential impact of its blasting operations on groundwater availability and quality. These barangays in the municipalities of Camalig and Guinobatan rely on deep wells for daily water use. This study evaluates the social acceptability of quarry blasting's perceived impact on groundwater sustainability. Specifically, the study aims to define a half-kilometer proximity zone around quarry blasting sites and analyze spatial relationships with groundwater level change. Surveys conducted will assess community perceptions in water quality for the affected wells and provide links between household deep well dependence and perceived impacts, including qualitative observations will be examined. Affected wells and the sustainability risks will be determined through spatial and statistical analysis and actions to address community concerns and promote sustainable groundwater management in line with SDG 6 will follow through informed recommendations.

2. Methodology

This study used a mixed-methods approach to evaluate the perceived impacts of quarry blasting on groundwater sustainability and social acceptability. The methodology consisted of preliminary mapping, community surveying, data visualization, and impact analysis. Using QGIS 3.34 Prizren, coordinates of three IRDC quarry sites and six surrounding barangays were mapped, and a half-kilometer proximity zones were established. Field surveys were conducted using structured questionnaires with Likert scale items to assess household perceptions, with one household per deep well surveyed. A stratified opportunistic sampling approach targeted accessible wells within 0.5–1.5 km from the quarry. Deep wells were classified as affected or unaffected and mapped by proximity. Statistical analysis (z-test for proportions), spatial auto-correlation (Moran's I via GeoDa), and

thematic analysis of qualitative responses were used to interpret the perceived impacts and spatial patterns.

3. Results and Discussion

3.1 Groundwater Sharing and Vulnerability

About 58% of surveyed deep wells are shared by two or more households, with most serving 1 to 5 households, but some as many as 10 to 30. Sharing patterns reveal both resilience and vulnerability in groundwater access. While many households have individual wells, shared sources, particularly those serving larger groups, are more susceptible to stress, especially during groundwater declines. This is critical near quarry sites (0.5–1.5 km), where blasting may lower water levels or alter flow paths, disproportionately affecting communal wells. These shared wells, while essential, point out sustainability risks and should be prioritized in water management strategies linked to quarry operations.

3.2 Community Perceptions of Groundwater Changes

Survey results show mixed perceptions of blasting's impact on groundwater. While 51.6% disagree that blasting affects groundwater levels, 25.3% agree, and 1.1% strongly agree, indicating some concern. Additionally, 22% are uncertain, reflecting varied awareness. Responses on well declines also vary: 39.6% disagree, 35.2% agree, and 23.1% are uncertain. This suggests that the impact of blasting may differ across households and locations.

3.3 Statistical Analysis

The z-test for proportions shows that quarry blasting has no significant impact on deep wells across buffer zones. Most zones showed no deviation from the 0.5 benchmark, indicating that blasting's perceived effects are not widespread. While Zone 2 matched the benchmark exactly, Zones 1, 1.5, and 2 showed no significant differences. This suggests that blasting does not significantly affect groundwater availability in these areas. However, the result in Zone 6, where no wells were affected, highlights potential localized variations, warranting further investigation into geological conditions or mitigation measures.

3.3 Spatial Analysis

Figure 1, created using QGIS, shows the distribution of affected (red) and unaffected (white) deep wells across buffer zones. The dispersed pattern, with no clustering near the quarry, suggests that proximity does not significantly influence perceptions of groundwater status, indicating limited broad-scale impacts. However, localized disparities highlight the need for site-specific assessments to ensure long-term water sustainability. Spatial autocorrelation analysis using GeoDa showed a weak positive correlation (Moran's $I = 0.040$) among affected wells, but the z-test indicated no statistically significant clustering, suggesting randomness. A regression analysis of quarry proximity and the proportion of affected wells showed a weak inverse relationship ($R^2 = 0.3288$, adjusted $R^2 = 0.1610$), with

closer wells slightly more affected. However, this result was not statistically significant ($p = 0.2341$), suggesting that proximity alone does not explain the perceived impacts. These findings imply that groundwater sustainability is influenced by a broader range of factors beyond quarry proximity.

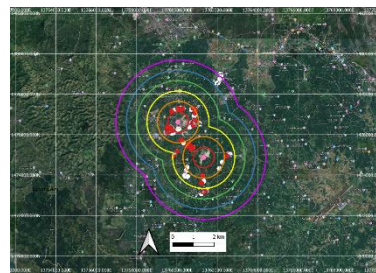


Figure 1. Affected and Unaffected Deep Wells

3.4 Thematic Analysis

Several respondents reported foreign materials in their water, such as sand, pebbles, small shrimps, worms, and red-colored substances, which they often linked to quarry blasting. They speculated that blasting vibrations might disturb the aquifer, allowing these materials into the water. These occurrences could result from vibrations dislodging sediments or creating pathways for surface materials to enter groundwater (Kernen, 2019). The red substances may be iron oxide or related to microbial activity, possibly triggered by geological disturbances (Perez-Guzman et al., 2010). While these perceptions are not confirmed causes, natural processes or seasonal changes might also explain them. Further investigations, including water quality and sediment analysis, are needed to clarify the role of blasting and guide appropriate actions.

4. Conclusion and Recommendations

This preliminary assessment examined the perceived impacts of quarry blasting on groundwater sustainability in Camalig and Guinobatan, Albay. The findings indicate that quarry blasting does not significantly affect deep well groundwater levels, but with reported issues like sand, worms, and red particles not linked to quarry proximity. These perceptions suggest that other factors, such as hydrogeological variability and well construction, may have a greater influence on groundwater conditions. The study highlights the importance of further investigations into water sustainability, recommending regular water and sediment monitoring, improved well maintenance, and long-term monitoring to better understand seasonal and climate impacts.

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