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A GIS approach to evaluating bank-filtration occurence and potential in the province of Quebec, Canada

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EXTENDED ABSTRACT

1. Background

In reviews of the international use of bank filtration (Dillon et al., 2019; Stefan & Ansems, 2017), Canada and the province of Quebec in particular are completely overlooked. As of this point in time, no inventory of bank filtration sites exists and the extent of its use throughout the province remains unknown. There is however a high probability that induced bank filtration (IBF) is widely used. Indeed, Quebec is a province rich in both surface water and groundwater with 22% (MDDELCC, 2014) of its surface covered by water either in the form of lakes, rivers, or wetlands. It is estimated that Quebec contains 3% of the Earth's renewable freshwater resources (Boyer, 2008). In addition, Quebec was settled through its waterways which have had long term effects on its population distribution. These two factors mean that there is high probability that pumping wells are located in close proximity to surface water. The process of IBF is thus likely to be occurring in many of the municipalities throughout the province. Current regulations and guidelines exist in Quebec for protecting surface water and groundwater extractions from contamination but there is no regulation specific to hybrid groundwater-surface water systems(Act, 2019). Existing IBF sites are therefore necessarily treated as standard groundwater extractions. This means that even if the groundwater wells are located within a few meters of a water body, there are no protection guidelines for the nearby surface water. The objective of this study is to present a GIS method of quantification of IBF sites in the province of Quebec, where there is a crucial need for improved characterization and comprehensive management guidelines.

2. Material and methods

There are two main factors that will determine whether a well is pumping a mixture of surface water and groundwater. First, a hydraulic connection between the surface water and the aquifer is necessary. Second, since groundwater naturally discharges into surface water in the study region, it is necessary to pump a sufficient volume to reverse that natural gradient and draw surface water toward the pumping well. In the existing databases, this information is not available.

In order to estimate the number of sites with the limited information available, a series of steps were taken in order to calculate their distance from surface water bodies and use this to infer whether the two conditions are met. A database obtained from a series of regional studies (PACES) which integrated data from multiple sources (MELCC, 2009-2015) was used for the individual wells to perform a series of steps in QGIS. In order to calculate the distance between each well and the nearest water body, a cleaned version of the database was used with duplicate wells removed. The waterbody files for smaller zones within the province were converted from multipart to single part files in order for the conversion of lines to points to work properly. The waterbody outlines were then converted to points with a 2-meter spacing. The distance from each well was calculated for each of the waterbody zones. This generated multiple distances for each well corresponding to each of the zones that were then merged into a single file that was used to calculate the minimum value for each well. Once the minimum value had been calculated, it was possible to join the resulting file to the additional files containing pertinent information (i.e. aquifer type, waterbody type, etc.)

3. Results and discussion

The PACES database contained a variety of information including the type of aquifers exploited for certain wells (granular vs fractured). Of the roughly 181000 wells in the PACES database, only 10179 were reported as granular aquifers and 45649 in fractured aquifers, and the majority had undocumented aquifer type. By looking at a provincial map of the aquifer type, certain areas where there are very few or no wells exploiting granular aquifers were identified. This distribution could indicate that the aquifers are either not productive enough or that the granular deposit thickness is not sufficient to support a well. With this in mind, two main conclusions can be drawn. First, municipal wells that are in these areas and far from a lake or river are likely drilled in a fractured aquifer. Second, wells in these areas that are close to surface water bodies could be drilled there for the increased productivity associated with the alluvial deposits around those water bodies and the rapid recharge from the nearby waterbody.

Furthermore, a more detailed look at the distribution of wells versus the distance from surface water bodies, suggests that the highest density of wells is found in the first 250m near surface water bodies. After the 250m mark there is a gradual decrease in the number of wells. This could be related to two main possibilities. Firstly, as was mentioned previously, individuals are often settled near water bodies, either due to the town they live in being founded in those locations or the fact that there is a preference for waterfront properties for homes and cottages outside of the major metropolitan areas. Secondly, the spatial distribution of wells in the first 250m could be related to the sheer number of surface waterbodies throughout the province. In any case, we can conclude that there is likely some individuals who are also pumping a mixture of surface water and groundwater and inducing recharge of the aquifer through the banks of lakes or rivers.

4. Conclusions

Looking at individual wells provides some insights into the types of aquifers and the distribution of wells in proximity to surface water bodies. In addition, it can be used to target specific areas where aquifer conditions are more favourable for IBF. However, these individual wells are much less likely to be pumping large volumes and the probability of IBF prevalent in these wells is less likely than in municipal wells where much larger volumes are pumped on a consistent basis. The

study should therefore be repeated on municipal wells, although limited availability of data is expected.

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