Investigating Spatio-temporal Changes in Groundwater Quality for London Between 2000-2020

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Abstract

The groundwater is relatively a pure natural resource as compared to the surface water, but anthropogenic activities pose a threat to its purity and suitability for drinking purpose. Thus, monitoring of spatial and temporal variation of groundwater quality is very important for its management and protection. Geographical Information System (GIS) and statistics can be useful to monitor and evaluate the groundwater quality. For London, there is no comprehensive work in the last two decades for studying the spatio-temporal variation for monitoring groundwater quality and its parameters. We have used data samples from over 500 wells in London basin and the data is provided in free open access domain by Environment Agency. The Trilinear-Piper plot highlighted overall groundwater as dominant magnesium bicarbonate type. To study spatio-temporal variation in London's groundwater quality, several water quality parameters were considered, for example, nitrates, nitrites, hardness, sodium, Dissolved Oxygen (DO) and others. The concentration of nitrates and nitrites in groundwater were less than 10 mg/l and 0.02 mg/l respectively, at all times (except outliers), during our observation period i.e between the years 2000 and 2020. The groundwater hardness, sodium and DO varied between 50 mg/l to 2363 mg/l, 11 to 308 mg/l and 0 to 10.7 mg/l respectively. The spatial variation maps showed that there are localised patches of groundwater above acceptable Drinking Water Inspectorate (DWI) limits, but overall London's groundwater is of potable status. The variations in the range of each constituent were attributed to variation in geology of the London palaeogene aquifers and anthropogenic activities. The Pearson correlation coefficients showed that hardness and sodium are negatively corelated and, DO and sodium are also negatively correlated. The study can act as a guide for decision making and to flag contaminate of concern. It can be helpful to outline the suitability of groundwater for its intended purpose, identifying pollution inputs and assessing any spatio-temporal changes.

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Objectives:
- Study groundwater quality for London, from 2000 to 2020.
- Spatio-temporal variation of Hardness, Dissolved Oxygen (DO), Sodium, Nitrates, and Nitrite.
- Data analysis and visualization of open access integrated datasets.

Data and Methods used:
- Open access data obtained from water quality archive of Environment Agency (EA) for over 500 wells.
- R programming and GIS tools for Data analysis and visualization.
- London spatially divided into 5 subzones: Central, East, North, South, and West.
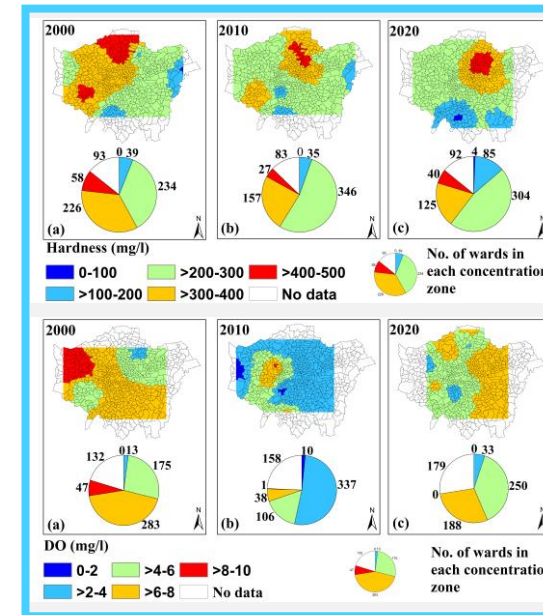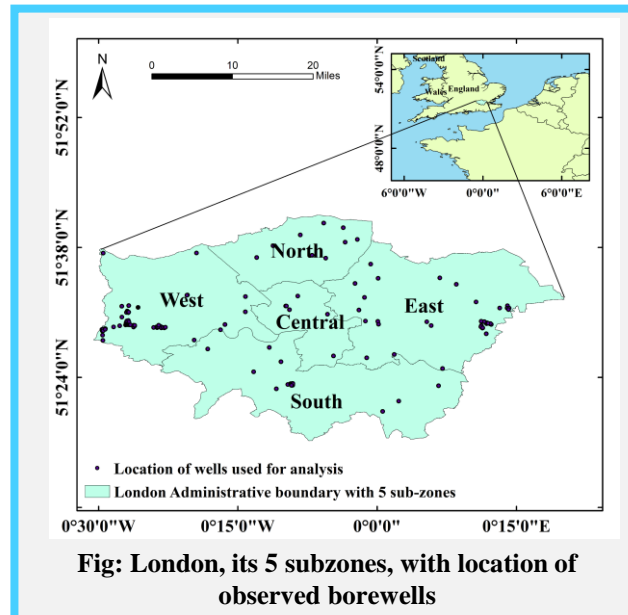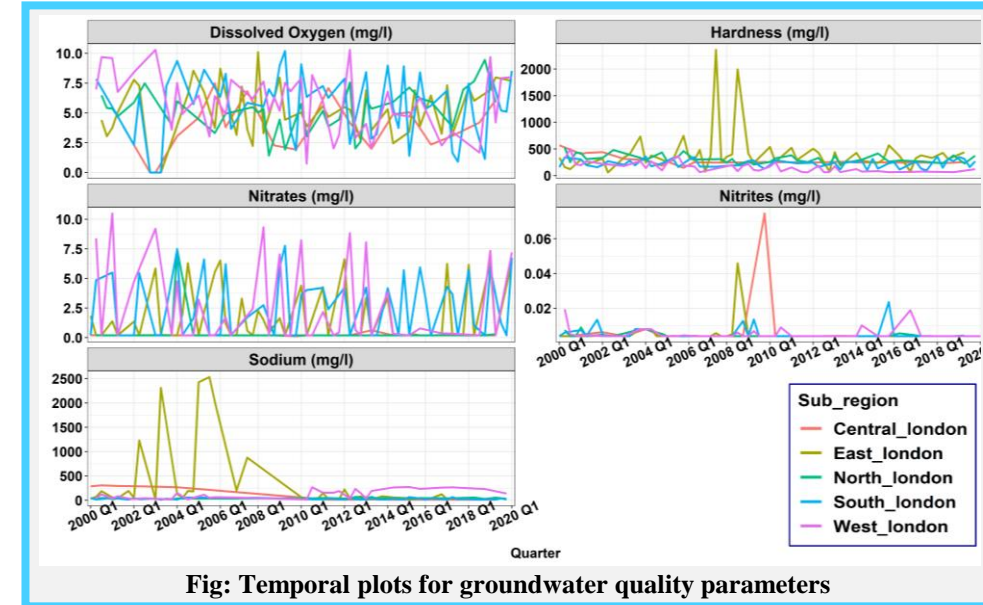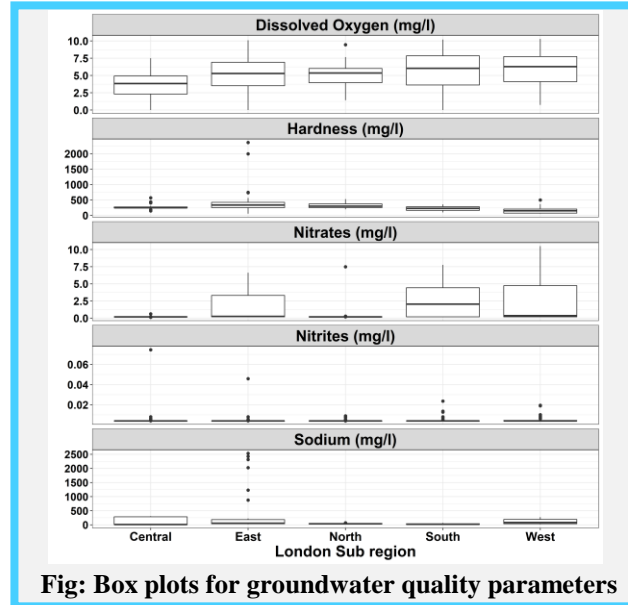- Temporal Analysis on quarterly basis:

Quarter 1 (Q1)	Winter	December, January, February
Quarter 2 (Q2)	Spring	March, April, May
Quarter 3 (Q3)	Summer	June, July, August
Quarter 4 (Q4)	Autumn	September, October, November

Significance:
- Sustainable management of groundwater resource.
- Mapping groundwater depletion areas for London.
- Needs for treatment of groundwater.
- Baseline for groundwater quality parameters.

Results:
- Overall groundwater of London: dominant magnesium bicarbonate type.
- From 2000 and 2020: the groundwater hardness range between 50 mg/l to 2363 mg/l, sodium between 11 to 308 mg/l and DO between 0 to 10.7 mg/l.
- Localised patches of different parameters below Drinking Water Inspectorate acceptable limits were found.

Fig: Box plots for groundwater quality parameters

Fig: Temporal plots for groundwater quality parameters

Fig: London, its 5 subzones, with location of observed borewells

- Spatial variation of Hardness and DO is shown.
- Similar variations can be shown for other parameters.
- Red and Orange areas represent localised zones of groundwater pollution, for a particular parameter.
- Temporal and box-plots shows time-series and statistical variation of different groundwater quality parameter.