Data Article

Data on the assessment of Groundwater Quality in Gomti-Ganga alluvial plain of Northern India

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\textbf{A B S T R A C T}

This data article deals with the assessment of groundwater quality based on water quality index (WQI) and irrigation indices. A total of 8 sites have been selected for the qualification of groundwater fitness. The assessment of groundwater quality has been done by selecting 13 physico-chemical parameters such as pH, EC, TDS, Ca\textsuperscript{2+}, Mg\textsuperscript{2+}, Na\textsuperscript{+}, K\textsuperscript{+}, Cl\textsuperscript{−}, SO\textsubscript{4}\textsuperscript{2−}, HCO\textsubscript{3}−, NO\textsubscript{3}−, F\textsuperscript{−}, and TH. Inverse distance-weighted (IDW) application was used to prepare the spatial distribution maps of WQI for the pre and post-monsoon period. All the samples were found in the rock dominance zone in Gibbs plot and according to the Piper plot, Ca-HCO\textsubscript{3} is the dominant hydrochemical facies in the study area. On the other hand, irrigation water quality was examined by computing irrigation indices such as SAR, RSC, SSP, MHR, KR, \%Na, PI, and PS. The outcomes of the irrigation indices suggests that the water quality is of a good and excellent category except for MHR and RSC.

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Specification table

| Subject                        | Environmental science                                      |
|-------------------------------|-----------------------------------------------------------|
| Specific subject area         | Water quality, groundwater management                     |
| Type of data                  | Table                                                     |
| How data was acquired         | Digital meter PC/301, CB18/945 Generic hand-held TDS-3 digital meter, Ion chromatography: Metrohm 792B-IC, Arc GIS version 10.4.1, Origin 8.5-Data analysis and graphic software. |
| Data Format                   | Raw Analyzed                                             |
| Parameters for data collection| A total of 13 physico-chemical parameters are selected (pH, EC, TDS, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, HCO<sub>3</sub><sup>-</sup>, NO<sub>3</sub><sup>-</sup>, F<sup>-</sup>, and TH) to collect the dataset for analysis of groundwater quality. |
| Description of data collection| Samples were collected according to the standard procedure in 1L clean polyethylene bottles in June, 2015 (8 samples in pre-monsoon season) and January, 2016 (8 samples in post-monsoon season). Above mentioned chemical parameters in the abstract section were analyzed as per the standard method. |
| Data source location          | Gomti-Ganga alluvial plain, Lucknow, Uttar Pradesh, India. The GPS coordinates of the sampling points are presented in Table 1. |
| Data accessibility            | Data are included in this article                         |

Value of data

- The data in this article gives an overview of groundwater quality that will help regulatory bodies and local authorities to improve and develop preventive measures for safe drinking and irrigation water use.
- This data article proven the implication of water quality indices that would be valuable for decision-makers and governing bodies to implement the appropriate management plan.
- The Gibbs plot can be used to understand natural groundwater chemistry and its control mechanisms. In addition, piper diagram help in determining the hydrochemical facies of groundwater.
- This data article can help to understand the ion exchange processes, the origin of ion elements and concentrations in groundwater in the study area.
- This regional-scale study in the field of groundwater quality can help in the management and mapping of groundwater on a high-resolution scale in a global way.

1. Data

This data article contains 9 tables and 7 figures to describe the quality of groundwater used for drinking and irrigation. The accuracy of data is verified by calculating the percent charge balance error (%CBE) shown in Table 1. Fig. 1 represents the study area location along with sampling points. The field observations and laboratory analysis of physico-chemical data

Table 1

Charge balance error values.

| Sample ID | %CBE Post monsoon | %CBE Pre monsoon |
|-----------|-------------------|------------------|
| LKO1      | 1.05              | 0.26             |
| LKO2      | 1.42              | -0.27            |
| LKO3      | 2.03              | 0.02             |
| LKO4      | 4.33              | 0.35             |
| LKO5      | -1.44             | 0.50             |
| LKO6      | -0.10             | 0.61             |
| LKO7      | 4.86              | -0.33            |
| LKO8      | -1.31             | -4.26            |
Table 2
Laboratory and field observation of hydrochemical data of groundwater.

| Sample | Co-ordinate (m) | pH | EC (µS/cm) | TDS (mg/L) | Ca<sup>2+</sup> (mg/L) | Mg<sup>2+</sup> (mg/L) | Na<sup>+</sup> (mg/L) | K<sup>+</sup> (mg/L) | Cl<sup>-</sup> (mg/L) | SO<sub>4</sub>²⁻ (mg/L) | HCO<sub>3</sub>⁻ (mg/L) | TH (mg/L) | F⁻ (mg/L) | NO<sub>3</sub>⁻ (mg/L) |
|--------|----------------|----|------------|-----------|-----------------------|----------------------|------------------|------------------|-----------------|----------------|----------------|--------|--------|------------------|
| 2016 (Post-Monsoon) | | | | | | | | | | | | | | |
| LKO1 | 81.03 26.62 | 8 | 560 | 364 | 36 | 33 | 36 | 4.5 | 14 | 3 | 342 | 225.2 | 0.2 | 0 |
| LKO2 | 81.12 26.74 | 8.1 | 462 | 300 | 40 | 28 | 16 | 2.8 | 7.1 | 16 | 268 | 215.2 | 0.6 | 0.34 |
| LKO3 | 80.85 26.72 | 8.1 | 585 | 380 | 32 | 39 | 35 | 4.4 | 28 | 10 | 317 | 240.2 | 0.2 | 0.09 |
| LKO4 | 80.94 27.04 | 8.5 | 520 | 338 | 20 | 30 | 49 | 5.6 | 18 | 12 | 275 | 175.1 | 0.7 | 0 |
| LKO5 | 80.73 27.03 | 8.1 | 754 | 490 | 68 | 36 | 37 | 5.2 | 28 | 31 | 421 | 320.3 | 0.6 | 0.25 |
| LKO6 | 80.69 26.93 | 8 | 615 | 400 | 48 | 20 | 37 | 14 | 17 | 366 | 290.2 | 0.7 | 1.2 |
| LKO7 | 80.78 26.87 | 8.2 | 662 | 430 | 48 | 39 | 44 | 4.3 | 17 | 310 | 280.2 | 0.9 | 31 |
| LKO8 | 80.94 26.86 | 8.2 | 738 | 480 | 60 | 36 | 37 | 4.8 | 57 | 46 | 325 | 300.2 | 0.3 | 108 |
| 2015 (Pre-Monsoon) | | | | | | | | | | | | | | |
| LKO1 | 81.03 26.62 | 8.2 | 320 | 214 | 28 | 19 | 10 | 2.4 | 7 | 2.2 | 195 | 150 | 0.3 | 0.6 |
| LKO2 | 81.12 26.74 | 8 | 614 | 411 | 36 | 34 | 48 | 2.8 | 21 | 19 | 354 | 230 | 0.1 | 1.9 |
| LKO3 | 80.85 26.72 | 7.9 | 426 | 285 | 36 | 27 | 13 | 3.8 | 7 | 4.3 | 268 | 200 | 0 | 0.4 |
| LKO4 | 80.94 27.04 | 8 | 591 | 396 | 32 | 32 | 51 | 4.8 | 21 | 6.3 | 354 | 210 | 0.2 | 0.3 |
| LKO5 | 80.73 27.03 | 8.1 | 472 | 316 | 20 | 41 | 17 | 4 | 14 | 18 | 268 | 220 | 0.5 | 0.2 |
| LKO6 | 80.69 26.93 | 7.9 | 567 | 380 | 36 | 36 | 28 | 5.8 | 7 | 2.5 | 354 | 240 | 0.2 | 0.3 |
| LKO7 | 80.78 26.87 | 8.2 | 790 | 529 | 56 | 58 | 24 | 3.8 | 28 | 47 | 427 | 380 | 0.0 | 1.1 |
| LKO8 | 80.94 26.86 | 7.9 | 710 | 473 | 61 | 37 | 35 | 4.7 | 59 | 45 | 355 | 310 | 0.3 | 108 |

Units of all the parameters expressed in mg/L, except pH and electrical conductivity expressed in µS/cm.

is presented in Table 2. The data from Table 2 are used to calculate the water quality index (WQI) which is summarized in Tables 3–5. Correlation analysis is a prevalent and widely used approach between hydro-geologists and environmental researchers, which helps to broadly understand rock-water interactions and weathering processes based on association values of physio-chemical parameters, shown in Table 6. Furthermore, Fig. 2 represents the spatial distribution maps of WQI in pre (2015) and post monsoon (2016) period. The TDS values are plotted against the cation ratio (Na<sup>+</sup> + K<sup>+</sup>) / (Na<sup>+</sup> + K<sup>+</sup> + Ca<sup>2+</sup>) and the anion ratio (Cl<sup>-</sup>) / (Cl<sup>-</sup> + HCO<sub>3</sub>⁻), which is shown in Fig. 3. To infer the hydrochemical facies of groundwater, the piper [1] trilinear plot is presented in Fig. 4. The equations for calculating irrigation water quality indexes and ratios such as SAR, RSC, SSP, MHR, KR, %Na, PI, and PS are summarized in Table 7 and the outcomes are shown in Tables 8–9. The graph between Electrical Conductivity (EC) and percent sodium (% Na), while between EC and SAR is shown in Figs. 5 and 6, respectively. Similarly Fig. 7 classifies irrigation water in three classes.
Fig. 2. Spatial distribution map of groundwater quality index (a) 2016: Post monsoon (b) 2015: Pre monsoon.

Fig. 3. Gibbs plots a. TDS vs (Na + K)/(Na + K + Ca) b. TDS vs Cl/(Cl + HCO₃).
Table 3
Assigned and relative weight for computing WQI as per BIS standards 2012.

| Parameter          | BIS standards (2012) (Desirable limit) mgL⁻¹ | Assigned Weight(wi) | Relative weight(RWi) |
|--------------------|---------------------------------------------|---------------------|----------------------|
| Calcium (Ca²⁺)     | 75                                          | 2                   | 0.06                 |
| Magnesium (Mg²⁺)   | 30                                          | 2                   | 0.06                 |
| Sodium (Na⁺)       | 200₁                                        | 3                   | 0.09                 |
| Potassium (K⁺)     | 12₁                                         | 2                   | 0.06                 |
| Nitrate (NO₃⁻)     | 45                                          | 5                   | 0.15                 |
| Sulphate (SO₄²⁻)   | 200                                         | 3                   | 0.09                 |
| Bicarbonate (HCO₃⁻)| 200                                         | 3                   | 0.09                 |
| Total Hardness (TH)| 200                                         | 3                   | 0.09                 |
| Fluoride (F⁻)      | 1                                           | 5                   | 0.15                 |
| Total Dissolved Solid (TDS)| 500 | 5 | 0.15 |

Σ wi = 34  Σ RWi = 1

* values are taken from WHO [5] guideline.

Table 4
Groundwater quality category based on WQI [6].

| S No. | Range | Category              | No. of Samples | Sample (%) |
|-------|-------|-----------------------|----------------|------------|
|       |       |                       | 2015 (PreM) 2016 (PosM) | 2015 (PreM) 2016 (PosM) |
| 1     | <25   | Excellent water       | 0 0             | 0 0         |
| 2     | 25-50 | Good water            | 6 4             | 75 50       |
| 3     | 50-75 | Fair water            | 1 3             | 12.5 37.5   |
| 4     | 75-100| Poor water            | 1 1             | 12.5 12.5   |
| 5     | 100-150| Very poor water       | 0 0             | 0 0         |
| 6     | >150  | Unsuitable for drinking | 0 0             | 0 0         |

Table 5
Groundwater quality index classification for individual sample based on WQI.

| Sample No. | WQI | Water quality category |
|------------|-----|------------------------|
| 2016 (Post-Monsoon) |     |                        |
| LKO-1      | 41.9 | Good water             |
| LKO-2      | 42.0 | Good water             |
| LKO-3      | 44.7 | Good water             |
| LKO-4      | 45.3 | Good water             |
| LKO-5      | 60.5 | Fair water             |
| LKO-6      | 55.6 | Fair water             |
| LKO-7      | 68.9 | Fair water             |
| LKO-8      | 89.9 | Poor water             |
| 2015 (Pre-Monsoon) |     |                        |
| LKO-1      | 27.4 | Good water             |
| LKO-2      | 43.5 | Good water             |
| LKO-3      | 32.1 | Good water             |
| LKO-4      | 43.4 | Good water             |
| LKO-5      | 43.2 | Good water             |
| LKO-6      | 44.8 | Good water             |
| LKO-7      | 58.6 | Fair water             |
| LKO-8      | 90.3 | Poor water             |

2. Experimental design, materials and methods

2.1. Study area description

Lucknow district is a flat alluvial area spread over about 2528 km², located in the state of Uttar Pradesh, India, between latitudes 26°30’ to 27°10’ N and 80°30’ to 81°13’ E longitudes,
### Table 6
Correlation matrix between physico-chemical parameters of groundwater samples.

|       | pH  | EC   | TDS  | Ca²⁺ | Mg²⁺ | Na⁺  | K⁺  | Cl⁻ | SO₄²⁻ | HCO₃⁻ | TH   | F⁻   | NO₃⁻ |
|-------|-----|------|------|------|------|------|------|------|--------|--------|------|------|------|
| pH   | 1   | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1      | 1      | 1    | 1    | 1    |
| EC   | -0.06 | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1      | 1      | 1    | 1    | 1    |
| TDS  | -0.10 | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1      | 1      | 1    | 1    | 1    |
| Ca²⁺ | -0.17 | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1      | 1      | 1    | 1    | 1    |
| Mg²⁺ | -0.34 | 0.56 | 0.56 | 0.21 | 0.14 | 1    | 1    | 1    | 1      | 1      | 1    | 1    | 1    |
| Na⁺  | -0.60 | 0.58 | 0.38 | 0.22 | 0.28 | 0.27 | 1    | 1    | 1      | 1      | 1    | 1    | 1    |
| K⁺   | -0.19 | 0.70 | 0.70 | 0.79 | 0.88 | 0.41 | 0.19 | 1    | 1      | 1      | 1    | 1    | 1    |
| Cl⁻  | -0.13 | 0.30 | 0.77 | 0.16 | 0.05 | 0.20 | 0.72 | 1    | 1      | 1      | 1    | 1    | 1    |
| SO₄²⁻| -0.17 | 0.96 | 0.96 | 0.67 | 0.78 | 0.62 | 0.50 | 0.62 | 1      | 1      | 1    | 1    | 1    |
| HCO₃⁻| 0.07  | 0.11 | 0.11 | 0.38 | 0.78 | 0.19 | 0.29 | 0.64 | 0.84   | 1      | 1    | 1    | 1    |
| TH   | 0.01  | -0.23 | -0.24 | -0.38 | -0.13 | -0.05 | 0.21 | 0.15 | -0.05 | -0.34 | -0.25 | 1    | 1    |
| F⁻   | -0.39 | 0.40 | 0.39 | 0.68 | 0.06 | 0.18 | 0.24 | 0.90 | 0.60   | 0.19  | 0.39 | 0.29 | 1    |

### Table 7
Summary of irrigation water quality indices equations [10-15].

| S.No. | Indices                  | Acronym | Formula |
|-------|--------------------------|---------|---------|
| 1     | Sodium Absorption Ratio  | SAR     | \(\text{SAR} = \frac{\text{Na}}{\text{Ca} + \text{Mg}}\) |
| 2     | Residual Sodium Carbonate| RSC     | \(\text{RSC} = [(\text{CO}_3^{-} + \text{HCO}_3^{-}) - ((\text{Ca} + \text{Mg})] \times 100\) |
| 3     | Soluble Sodium Percentage| SSP     | \(\text{SSP} = \frac{\text{Na}}{\text{Ca} + \text{Mg} + \text{Na}} \times 100\) |
| 4     | Magnesium Hazard Ratio   | MHR     | \(\text{MHR} = \frac{\text{Mg}}{\text{Ca} + \text{Mg}} \times 100\) |
| 5     | Kelly's Ratio            | KR      | \(\text{KR} = \frac{\text{Na}}{\text{Ca} + \text{Mg} + \text{Na}} \times 100\) |
| 6     | Percent Sodium           | %Na     | \(\%\text{Na} = \frac{\text{Na}}{\text{Ca} + \text{Mg} + \text{Na}} \times 100\) |
| 7     | Permeability Index       | PI      | \(\text{PI} = \frac{\text{Na} + 0.5 \times \text{HCO}_3^{-}}{\text{Na} + 0.5 \times \text{HCO}_3^{-}} \times 100\) |
| 8     | Potential Salinity       | PS      | \(\text{PS} = \frac{\text{Ca} + \text{Mg}}{\text{Cl} + 0.5 \times \text{SO}_4^{2-}} \times 100\) |

and its elevation is about 103 m to 130 m amsl (Fig. 1). The sampling site has been chosen to collect the sample in such a way that it can give proper information about the ground water quality of the entire district. The Gomti River is mainstream of Lucknow district, flows from the central part of the district which splits the investigation area into two parts namely, Cis and Trans Gomti. Furthermore, Gomti-Ganga alluvial is divided into older and younger alluvium of quaternary age is the major geographic unit of the district. Older alluvium in the highland area composed of 3.3 to 6.5 ft. thick fine silty sand with scattered coverings of calcrite nodules while newer alluvium in lowland regions comprises silt, sand, and clay. Although, Central Ground Water Board (CGWB) dug several exploratory boreholes between 328 and 2470 ft. below ground level (bgl) and revealed that five aquifer groups exist in the area. In the present investigation area, both confined and unconfined aquifer systems are extensively used for domestic and irri-
Fig. 4. Piper’s Trilinear plot of major ion data of groundwater samples.

Table 8

Calculated values of irrigation water quality indices.

| Sample No. | SAR      | RSC      | SSP      | MHR     | KR       | %Na     | PI    | EC   | PS     |
|------------|----------|----------|----------|---------|----------|---------|------|------|-------|
| **2016** (Post-Monsoon) |          |          |          |         |          |         |      |      |       |
| LKO-1      | 1.042544 | 1.09310  | 25.76386 | 60.18391| 0.347053 | 27.14353| 39.90986 | 560  | 0.427195 |
| LKO-2      | 0.474628 | 0.09213  | 13.92992 | 53.58062| 0.161844 | 15.14622| 37.02259 | 462  | 0.366852 |
| LKO-3      | 0.982082 | 0.38926  | 24.05626 | 66.77378| 0.316764 | 25.38314| 37.02259 | 585  | 0.889787 |
| LKO-4      | 1.618882 | 1.04033  | 38.07333 | 71.21011| 0.614813 | 39.61824| 39.25198 | 520  | 0.632685 |
| LKO-5      | 0.902807 | 0.54409  | 20.20551 | 46.60913| 0.253219 | 21.51601| 34.17892 | 754  | 1.112573 |
| LKO-6      | 0.512214 | 0.22931  | 13.10341 | 58.48017| 0.146913 | 14.3576 | 52.20749 | 738  | 0.208678 |
| LKO-7      | 0.961408 | -0.52391 | 22.3952  | 57.26096| 0.287159 | 23.50288| 32.48741 | 662  | 1.389956 |
| LKO-8      | 0.932570 | -0.63004 | 21.27167 | 49.73300| 0.270191 | 22.52876| 31.74922 | 738  | 2.086786 |

| Sample No. | SAR      | RSC      | SSP      | MHR     | KR       | %Na     | PI    | EC   | PS     |
|------------|----------|----------|----------|---------|----------|---------|------|------|-------|
| **2015** (Pre-Monsoon) |          |          |          |         |          |         |      |      |       |
| LKO-1      | 0.357500 | 0.23514  | 12.80944 | 52.80655| 0.146913 | 14.3576 | 52.20749 | 320  | 0.220365 |
| LKO-2      | 1.377554 | 1.20748  | 31.24545 | 60.89706| 0.454449 | 31.9745 | 37.82385 | 614  | 0.790185 |
| LKO-3      | 0.398933 | 0.37403  | 12.33633 | 55.29169| 0.140723 | 14.15652| 45.43549 | 426  | 0.242227 |
| LKO-4      | 1.525357 | 1.57167  | 34.40141 | 62.24935| 0.524423 | 35.62697| 38.9621 | 591  | 0.65797 |
| LKO-5      | 0.500l41 | 0.02045  | 14.46701 | 77.17088| 0.16914  | 16.14543| 41.04004 | 472  | 0.582313 |
| LKO-6      | 0.789556 | 1.04291  | 20.37757 | 62.24935| 0.255928 | 22.30596| 40.69097 | 567  | 0.223488 |
| LKO-7      | 0.536684 | -0.56907 | 12.12301 | 63.07037| 0.137954 | 13.10378| 31.5189 | 790  | 1.279143 |
| LKO-8      | 0.872532 | -0.27056 | 20.00236 | 50.00474| 0.250037 | 21.24621| 32.84148 | 710  | 2.132793 |
gation use. In addition, the pre and post-monsoon depths of the water level are 17.06 to 127.28 ft. and 5.28 to 93.17 ft., respectively [2].

2.2. Sampling and Laboratory analysis

Groundwater samples were collected from 08 shallow boreholes (Fig. 1). A total of 16 samples were collected (8 samples in pre monsoon and 8 samples in post monsoon) according to the standard procedure in 1L clean polyethylene bottles and noted the GPS coordinates of sampling point (Table 2) during the pre-monsoon (2015) and post-monsoon period (2016). The pH and EC were measured on site using PC/301, while Total dissolved solids (TDS) were measured using CB18/945 Generic hand-held TDS/3 digital meter. Total Hardness (TH) was determined by Ethylene Diamene Tetra Acetic Acid (EDTA) titrimetric method using Black-T indicator. Samples were filtered using cellulose filters (0.45µm) for determining the cations and anions using ion chromatography (Metrohm 792B-IC), which showed an accuracy of ±2%. Cations were measured using Metrosep C2/100 column such as Na⁺, K⁺, Ca²⁺, Mg²⁺, while Metrosep A Supp 4/250 was used to measure the anions such as F⁻, Cl⁻, SO₄²⁻, NO₃⁻, HCO₃⁻. The charge-balance error was calculated to check the veracity of the chemical analysis using Eq. 1 and found to be within the allowable range of (±) 5% [3] which is presented in Table 1.

\[
\% \text{CBE} = \frac{\sum \text{TA} - \sum \text{TC}}{\sum \text{TA} + \sum \text{TC}} \times 100
\] (1)
3. Evaluation of groundwater quality index for drinking

The cumulative effect of different hydrochemical parameters on groundwater quality varies. The relative weight (RWi) of individual parameters has been calculated using Eq. (2):

\[ RWi = \frac{w_i}{\sum_{i=1}^{n} w_i} \]  

Where, \( w_i \) represents the assigned weight and \( n \) represents the number of parameters used in the analysis. The relative rate (RRi) of each parameter is computed using Eq. (3):

\[ RRi = \frac{r_i}{BISi} \times 100 \]  

Where, \( r_i \) is ionic concentration of individual parameter, and BISi is the desirable limit recommended by BIS [4].

The WQI for each site is calculated by adding the standard index (Sli) values of the individual parameters using Eqs. (4) and (5), respectively:

\[ \text{Standard Index (Sli)} = RWi \times RRi \]  

\[ \text{Water Quality Index (WQI)} = \sum Sli \]
Fig. 6. USSL diagram, Salinity Hazard (EC) vs Sodium Hazard (SAR).

Fig. 7. PI vs Total concentration (in meqL⁻¹).
3.1. Evaluation of groundwater quality indices and ratios for irrigation

In order to assess the quality of groundwater in relation to irrigation purpose, it is necessary to evaluate the composition and concentration of dissolved components [7-9]. Groundwater quality for irrigation purpose is explained on the basis of SAR, RSC, SSP, MHR, KR, % Na, PI, PS, and EC values are summarized in Tables 7-9. Wilcox [10], USSL [11], and Doneen [12] classifications are used to explain the suitability of groundwater for irrigation purposes shown in Fig. 5, Figs. 6 and 7, respectively.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dib.2020.105660.

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