Chapter: 6

Conclusions and Suggestion

6.1 Conclusions

Based on the findings from the present study it is concluded that the groundwater quality is deteriorated gradually around the Ramna and Karsara MSW dumping site of Varanasi city, due to leaching of its leachate and not safe for drinking purpose. The whole study has been summarized as follows:

The higher value of Leachate Pollution Index(LPI) indicates a hazardous and non-stabilized generated leachate from both the dumping site and a poor environmental conditions of the studied area.

Results of leachate characteristics clearly revealed the need for implementation of a suitable MSW leachate management of the Ramna and Karsara dumping sites. Heavy metals (Cr, Cu & Fe) concentration was found in significant amount in both the MSW leachate samples indicating the dumping sites act as a point source of the toxic pollutant, While Cd, Pb, Ni, Mn, and As analysis showed no significant threat to any of the dumping site. Low BOD_5/COD ratio (0.26 and 0.16) revealed that both the dumping sites are categorized by methanogenic conditions. The concentration of contaminants of leachate at Karsara dumping site was comparatively greater than that of Ramna dumping site indicates Karsara dumping site is more polluted.

The open well's water around the Ramna dumping sites is not potable as most of the physico-chemical parameter values exceed the permissible limit of drinking water standard prescribed by WHO &BIS. The physico-chemical characteristic of groundwater quality near the Ramna MSW dumping site showed that the open dumping site leads to a considerable threat to local aquifer of the nearby area. In post-monsoon, the concentration of NO_3^-, PO_4^{3-}, Fe, ECand TDS were found to increase in the groundwater which is mainly due to percolation or direct discharge of leachate with

rainwater. Factor analysis of Ramna groundwater quality data suggests that the first six components are sufficient to explain the monitoring area. Factor analysis signifies positive loading of EC, TDS, chloride, hardness, and Na which shows MSW impact on groundwater quality. Correlation matrix of data shows most of the parameter highly correlated during post-monsoon indicating the effect of leaching of contaminant during the rainy season from the dumping site. The overall multivariate statistical analysis gives an effective interpretation of a large dataset for landfill groundwater quality analysis.

Evaluation ofWater Quality Index (WQI) revealed that 50% of groundwater samples around the Ramna dumping sites are excellent that encountered desirable level while 43.75% are good and 6.25 % are fair water quality for drinking purpose. During post-monsoon the quality of water significantly changes i.e. 37.5 % water samples are excellent, 25% are good and 37.5 % are fair water quality for drinking purpose. The WQI map shows that the maximum area comes under good water quality in pre-monsoon and fair water quality in post-monsoon which is acceptable for domestic purpose. Spatial spreading of water quality index indicated that the wells with fair water quality were located very close (500 m) to the dumping site. However, by analysis of groundwater characteristic, it was concluded that EC, TDS, hardness, nitrateand Fe were found above the standard limit of drinking water quality in both pre- and post-monsoon period, which is not safe for drinking purpose.

The result of physico-chemical analysis of groundwater around the Karsara MSW dumping site has shown that groundwater is not safe for drinking purpose as some of the water quality parameters like TDS, hardness, total alkalinity, and nitrate and iron contents are observed to be above the acceptable limit drinking water quality in both pre- and post-prescribed byBureau of Indian Standard and WHO guideline. A

highvalue (18.55) of LPI of Karsara MSW leachates revealed the presence of significant amount of pollutants. Results of WQI indicated that 35% of groundwater samples were found to be good, 35% marginal, 20% excellent, and 10% were in the fair category during the pre-monsoon period of the year 2016, while in the post-monsoon period, 70 % of samples were marginal, 15% excellent, 10% fair, and 5% in good category. The WQI map of the study area near the Karsara dumping site shows that water quality lies in the fair category during pre-monsoon season but in the threatened category during post-monsoon season. Impact of the MSW was observed to be at maximum within 300 m toward the southwest of the dumping site in the study area. On the basis of the above findings, this is concluded that the groundwater quality has significantly deteriorated around the Karsara MSW dumping site. An inverse relation is observed between LPI of MSW leachate and WQI.

Groundwater flow modeling results revealed that increase in the hydraulic head during the post-monsoon responsible for the downward flow of leachate pollutants from the Ramna dumping and it might be because of groundwater contamination near to the landfill. The direction of groundwater flow also observed towards the deteriorated groundwater area which is very close to the landfill site.Groundwater flow around the Ramna dumping site is significantly influenced by the heads and its direction isfound towards the river with velocity $5.7x10^{-7}$ m/s.

TDS and Nitrate transport modeling showing a distinct pollutant path line from Ramna MSW dumping site to nearest observed wells and its path are towards the groundwater flow direction.

MSW dumping site should have a designed engineering model to mitigate the impact of MSW leachate on nearby groundwater.Lined engineered landfill and leachate collection ponds are the best way to protect the percolation of leachate into groundwater.

6.2 Future suggestion

Ramna and Karsara MSW dumping site can also act as a point source for nearest groundwater contamination in near future due to observed toxic constituents such as COD, TDS, chloride, and other heavy metals. The LPI and WQI can be a very useful information method for landfill design makers and the municipal authority.

The evaluation of landfills leachate characteristic would suggest a suitable treatment approach to reduce pollutants to satisfactory concentration before they are discharged into the surrounding environment.After closure, both the MSW landfills should be managed and controlled the potential leaching to escape adverse effects on human health and the environment with the final goal of succeeding functional stability. The closure of the landfill should include a complete assessment of the acceptability of the nearby groundwater quality. Typical physical, chemical treatments can be engaged to upgrade the leachate of the MSW dumping sites. By leachate treatment with reducing the aftercare period length of landfills both sustainability and financial benefits can be attained. The modeling approach can be used to execute assessments of the long-term emissions of the pollutant from MSW leachates and might be helpful to decide whether the residual emission potential is acceptable or notan advanced landfill concept referred to as a biocell, which involves the sequential application of anaerobic degradation, aerobic decomposition and waste mining.

This study is to be found in a scientific method for spatial pollution monitoring program. This study would be helpful for landfill strategy makers and the government

authorities to safeguard groundwater pollution risk from the landfill. The research finding can be very helpful in protecting the groundwater from good water quality to become threatened water in a future perspective. This study is also helpful for the suitable landfill site selection.

The study provide scientifically justified approach and transfer of knowledge between scientists of different disciplines, who will study aquifers with high pollutant concentrations which deteriorate groundwater quality and to transfer the knowledge to decision makers and local water-use groups to ensure environmentally sustainable management of water resources and agricultural production.

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List of Publications

1. **Mishra, S.,**Tiwary, D., Ohri, A.Agnihotri, AK., Assessment of groundwater quality using WQI and GIS near the Karsara municipal landfill site, Varanasi, India. Arabian Journal of Geosciences (2018) 11:252.
2. **Mishra, S**., Tiwary D., Ohri A. 2018. Leachate characterization and evaluation of leachate pollution potential of urban municipal landfill sites. *International Journal of Environment and Waste Management***,** (21 (4): 217-230
3. **Mishra, S.,**Tiwary D., Ohri A. 2018. Spatial analysis of groundwater quality around MSW landfill site. *Nature Environment and Pollution Technology***,** 17(3): 393-395.
4. **Mishra, Sachin**, AshaLata Singh, and DhaneshTiwary. "Studies of Physico-chemical Status of the Ponds at Varanasi Holy City under Anthropogenic Influences." *International Journal of Environmental Research and Development* 4.3 (2014): 261-268.
5. AnuragOhri, Prabhat Kumar Singh, Satya Prakash Maurya, **Sachin Mishra"**Sanitary Landfill Site Selection by Using Geographic Information System" *e- ProceedingsNational Conference on Open Source GIS: Opportunities and Challenges, Oct 9-10 2015.*
6. Akhtar, J. **Mishra, S.,**Ohri, A. Tiwary, D. Agnihotri, AK., (2018). Assessment of water quality of River Assi by using WQI, Varanasi, India. *International journal of environmental research and development*, *7*(1), 114-121.
7. Agnihotri, AK., Ohri, A., **Mishra, S.,** (2018). Impact of green spaces on the urban microclimate through landsat 8 and TIRS data, in Varanasi, india. *International journal of environmental research and development*, *7*(1), 72-80.

8. SatyaPrakashMaurya, AnuragOhri, **Sachin Mishra"**Open Source GIS: A Review" *e- ProceedingsNational Conference on Open Source GIS: Opportunities and Challenges Oct 9-10 2015.*
9. Ashwani Kumar Agnihotri , AnuragOhri, **Sachin Mishra** "Channel planform dynamics of lower Ramganga River, Ganga Basin, GIS and Remote Sensing analyses." **Accepted** in Oct 2018 in Journal of Geocarto International
10. Sachin Mishra, AnuragOhri,DhaneshTiwary,andAshwani Kumar Agnihotri"Landfill leachate analysis and Its impact on groundwater quality."**Communicated** in journal of Sustainable Environment Research.

Paper Presented in Conferences

1. ***Mishra Sachin****, DhaneshTiwaryAnuragohri and Ashwani Kumar Agnihotri***.**(2018)"Assessment of groundwater quality using WQI and GIS near the Karsara Municipal landfill site, Varanasi." Paper presented in International Conference on Remote Sensing and GIS for Applications in Geosciences to be held on August 12, 2017 at the Department of Geology, Aligarh Muslim University, Aligarh, India.
2. **Mishra, S.,**Tiwary D., Ohri A. 2018. Spatial analysis of groundwater quality around MSW landfill site. *Nature Environment and Pollution Technology***,** 17(3): 393-395. Paper presented in International Conference on Liable Cities: Transforming Sustainability and its challenges at Department of Geography, SheedBhagat Singh college University of Delhi.
3. **Mishra, Sachin**, AshaLata Singh, and DhaneshTiwary. "Studies of Physico-chemical Status of the Ponds at Varanasi Holy City under Anthropogenic Influences." *International Journal of Environmental Research and Development* 4.3 (2014): 261-268". Paper presented in 2nd International Conference on Sustainable innovative Techniques in Civil and Environmental Engineering organized by KrishiSanskriti (JNU) New Delhi.
4. Akhtar, J. **Mishra, S.,**Ohri, A. Tiwary, D. Agnihotri, AK., (2018). Assessment of water quality of River Assi by using WQI, Varanasi, India. *International journal of environmental research and development*, *7*(1), 114-121. Paper presented in International Conference on Ajman 5th International Environmental Conference at Ajman Municipal and Planning Department , Ajman University, UAE

5. Agnihotri, AK., Ohri, A., **Mishra, S.,** (2018). Impact of green spaces on the urban microclimate through landsat 8 and TIRS data, in Varanasi, india. *International journal of environmental research and development*, *7*(1), 72-80. Paper presented in International Conference on Liable Cities: Transforming Sustainability and its challenges at Department of Geography, SheedBhagat Singh College University of Delhi.

Workshop/ Training Programme

1. Short-term National Training Programme on Instrumentation Application and Chemical Analysis for Environmental Sample organized by NIT Durgapur Kolkata (2014).
2. One week National workshop on BRNS-AEACI Eleventh School on Analytical Chemistry-2015 organized by Board of research in Nuclear Science Bhabha Atomic Research Centre, Trombey, Mumbai (2015).
3. Two weeks National workshop on Water and Wastewater Treatment organized by MCIIE, IIT (BHU) Varanasi (2015).
4. One Week National Workshop on Understanding Statistics by MS-Excel and SPSS organized by DST Centre for Interdisciplinary Mathematical Science, BHU, Varanasi(2015).
5. One day workshop on Open source GIS organized by Department of Civil Engineering IIT (BHU) (2015).
6. Five days National workshop on Identification of Contaminated Sites & Its Treatment Technology organized by Department of Hydrology IIT Roorkee, (2016).
7. Four days International workshop on "Geo-statistical Analysis of Environmental Data" organized by National Institute Of technology Surathkal, Karnataka (2016).
8. Four Weeks National workshop on Entrepreneurship Development Programme organized by MCIIE, IIT (BHU) Varanasi (2016).
9. One day author workshop organized by Springer Nature and IIT (BHU) (2016).
10. One day National workshop on Rain water Harvesting and Groundwater Recharging organized by Department of Civil Engineering IIT (BHU) (2016).

11. Six days national workshop on “Environmental Law: contemporary issue and challenges organized by Faculty of Law Legal Aid and Service Clinic BHU, Varanasi (2017).
12. One week National workshop on Techniques in Hyperspectral data analysis and processing jointly organized by IESD (BHU) & Department of Physics IIT (BHU) (2017).
13. 12 days Biogas lab training programme conducted by German Biogas Association with support of Indian Biogas Association at MCIIE, IIT (BHU) Varanasi (2018).
14. Two week International workshop on “Aquatic Bio resource Biotechnology and Parasite Diversity organized by Department of Zoology” University of Allahabad (2012).
15. Two day national seminar on environmental concern and sustainable development organized by IESD (BHU) Varanasi (2012).