Eco. Env. & Cons. 28 (2) : 2022; pp. (915-921)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i02.052

Experimental Investigation and Modeling on Impacts of Leachate from Bio-manures and Fertilizers Used in the Agricultural Fields Along Noyyal River

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(Received 3 April, 2021; accepted 22 May, 2021)

ABSTRACT

Agriculture is the back bone of India and it is the source of life for all the people who thrive to live. But in the recent years, the biological hazards like bio- accumulation and environmental ill-effects like Eutrophication due to the impacts of improper fertilization and leaching of bio-manures and fertilizers into the ground water aquifers from the agricultural fields. Thus this project shows a clear view on the impacts of leached bio-manures and fertilizers/pesticides over the ground water aquifers along Noyyal River, Coimbatore-South (10.9899° N, 76.8409° E), Tamil Nadu. The modelling of the sampling stations from 5 km buffer region along the river which predicts the impacts in the form of map using the GIS software. Ten samples per season are collected from 10 different sampling stations and the seasons are namely the winter and the monsoon seasons. The physical, chemical, mineral and biological tests are carried out and it is inferred with the allowable limits (WHO) for both the seasons and the tests are namely pH, Hardness, Alkalinity, Phosphate, Potassium and Conductivity. The pH values varying from 6.5 to 8.1, the hardness values varying from 37.6 ppm to 567.4 ppm, Alkalinity values varying from 35 ppm to 155 ppm, Phosphate values varying from 1.87 ppm to 4.89 ppm, Potassium values varying from 3 ppm to 27 ppm and Electrical conductivity values varying from 120 m/cm to 930 m/cm are identified. For the turbidity test, the test results from all the sampling stations are exceeding the allowable limits in both the seasons with the values ranging from 16.4 NTU to 20.8 NTU. The Plate count test values ranging from 120 Cfu/ml to 610 Cfu/ml where the field 6 exceeds the allowable limit and for the Nitrate test values ranging from 0 ppm to 70 ppm where the field 8 exceeds the allowable limit. From the GIS map obtained it is inferred that the pH, alkalinity, plate count values of fields using bio-manure are less and the fields using fertilizers are high during the winter season; whereas the values of fields using bio-manure are high and the fields using fertilizers are less during the monsoon season. From the nitrate, phosphate, potassium and conductivity tests it is inferred that in winter season all the fields are having less values and in monsoon season all the fields are having high values. To overcome the water supply demand, water treatment for the high water toxic areas are necessity. The sampling points having high turbidity (all Fields) can employ coagulation and sedimentation using alum stones, for the high Nitrates (Field: 8) Reverse osmosis can be carried out and for high total solids (Field: 2, 4, 5, 7) activated carbon filters can be implemented. The safest sampling stations were identified.

Key words : *Eutrophication, Leachate, Bio-manures, Fertilizers/Pesticides, Noyyal river, Sampling stations, Seasonal variations, Water characteristics, Allowable limits, GIS Software, Buffer region, Risk analysis, Purification techniques.*

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Introduction

India's population is expected to become the world's highest in the next 20 years; while its economy will soon overtake Japan's to become the world's third largest. The resulting increase in the demand for food will need to be met through higher agricultural productivity or by increasing food imports (Bettu Sudhakar, 2016). The Fertilizers and pesticides are playing an important role in the agricultural fields and it is used to increase the crop yield due to high demand of the food/commodity/goods. Agriculture is the most important sector of Indian Economy. Indian agriculture sector accounts for 18% of India's Gross Domestic Product (GDP) and provides employment to 50% of the countries workforce (Madhusudhan, 2015). At present India is shifted to chemical farming from organic which provides more yield; but creates immense health problems. Exposure to pesticides both occupationally and environmentally causes a variety of human health problems. At present, India is the largest producer of pesticides in Asia and ranks twelfth in the world for the use of pesticides. Many of the chemical pesticides can have harmful effects on human beings either as acute or chronic toxicity. Acute exposure to pesticides can lead to death or serious illnesses. About 355,000 people die globally each year due to unintentional acute poisonings. Two-thirds of deaths occur in developing countries where such poisonings are associated with excessive exposure and or inappropriate use of toxic chemicals and pesticides present in occupational and domestic environments (Nadimidoddi Leela Sharon, 2014). The Fertilizers and pesticides are good for the harvesters in terms of crop production where as on the other hands they also influence the under-ground water aquifers. The accelerated use of agricultural chemicals over the past 20 to 30 years has profitably increased production but has also had an adverse impact on ground water quality in many of the major agricultural areas of the world. The pollution of ground water, related to nitrogen fertilizers and pesticides, from widespread, routine land application, as well as point sources has become a serious concern. Ground water contributions also impair surface water quality. Research, worldwide, has shown rates of nitrate-nitrogen (NO3-N) increases in ground water typically between 0.1 to 1.9 mg/l per year for 10 to 20 years, concurrent with major increases in nitrogen fertilization (George R. Hallberg, 1987). Groundwater is considered a substantial source for drinking, agricultural and industrial activities in the semi-arid parts of India. Urban, semi-urban and rural areas of Indian states are mainly reliant on groundwater as approximately 85% rural domestic water demands and 50% urban potable water requirements are fulfilled by groundwater only (Ahada and Suthar, 2018a; Jain and Vaid, 2018). India is the first largest user of groundwater in the world with 251 km^3/year abstraction rate followed by China (112 km^3/year) and USA (112 km^3/year). Out of the total amount of groundwater extracted, largest share~89% is used by the agricultural sector particularly for irrigation purpose and remaining 11% for public water (domestic purpose) and industrial supply (World bank 2012; Margat and Gun 2013; Raju and Singh, 2017; Singh *et al.,* 2019b; Ahada and Suthar, 2018b). Different approaches are used for estimating groundwater vulnerability using remote sensing and GIS (Alina Barbulescu, 2020).

The project develops the model with the GIS application by interpreting the influence of Eutrophication in the under-ground water samples containing leached manure and fertilizer/pesticides from the agricultural fields in the selected regions along Noyyal river in Coimbatore to the water quality parameters and specifies the safest sampling stations which assures the health care and rectifies the water supply demand of the locality.

The main objectives of the study are to examine the physical, chemical, mineral and biological properties of the under-ground water containing leached manure and fertilizer/pesticides from the agricultural fields; Interpret and conclude the results with World Health Organization (WHO) and Indian Standards (IS); Generate the model by GIS software for easy examination; Predict the quality of ground water of sampling stations in 5 Km (Kilometre) buffer region along the Noyyal River and identify the safest station and suggest the water purification techniques in and around toxic sampling stations.

Methodology

The site selection and the sampling stations is set in such a way that they are apart from one another so as to get the wide range of results; the ground water samples are collected for both seasons and the laboratory tests are carried out to determine the physical, chemical, mineral and biological properties; from the obtained test results, GIS modeling is used

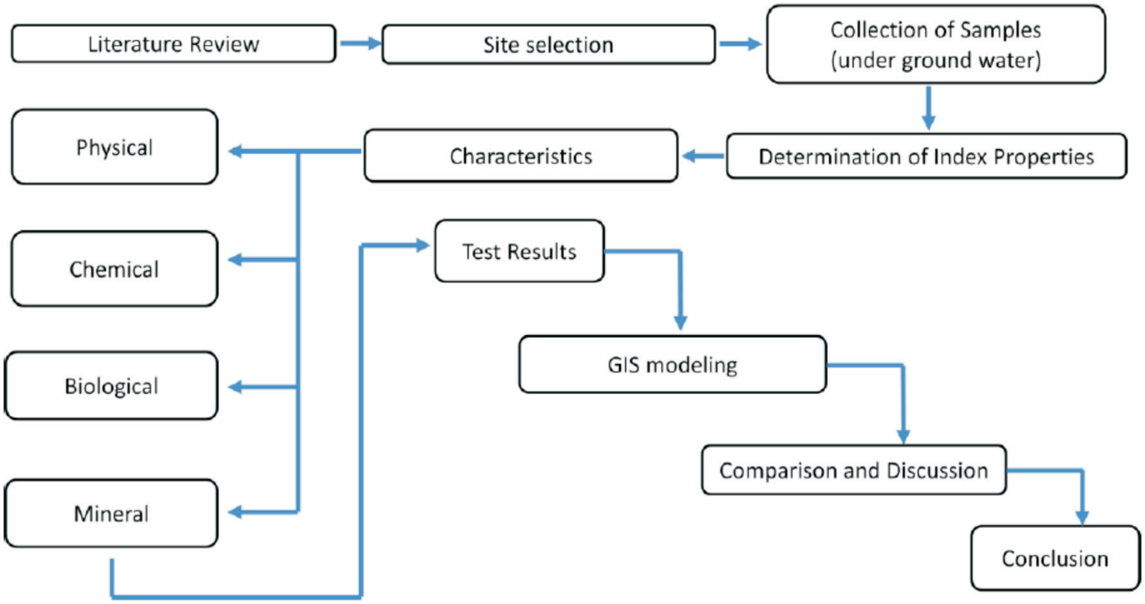

Fig. 1. Methodology of study

for comparisons and discussion of the impact prediction maps for the risks analyzed. Fig 1 represents the methodology of study.

Site Selection and Sample Stations

The Agricultural fields selected for obtaining the Aquifers samples are along with the Noyyal River (Fig. 2) which originates from the Western Ghats, Coimbatore, Tamil Nadu. The two major types of fertilization used in the agricultural fields are Bio-Manures and Fertilizers. From the literatures reviewed the site selection is done and the sampling stations is set in such a way that they are far apart from one another so as to get the wide range of results. Table 1 shows the sampling station with fertilization type and type of manures/fertilizers used corresponding to the field locations.

Laboratory Investigation

The four main index properties of water (Fig. 3) are

Table 1. Geographical Locations and Fertilization type of the fields for the Sampling Stations

Sampling Stations	Latitude	Longitude	Category of Fertilization	Biomanure/ Fertilizer Types Used
Field 1	10.9712	76.8325	Fertilizer	DAP (Di-Ammonium Phosphate), calcium Nitrate, Potassium Sulphate, Urea, Excelmera 70, Oxygold, Roundup
Field 2	10.9756	76.8389	Fertilizer	DAP, urea ,Excelmera 70, Oxygold, Roundup, Potassium Sulphate
Field 3	10.9726	76.8527	Manure	Cow dung
Field 4	10.9798	76.8627	Fertilizer	Potassium Sulphate, DAP, Urea
Field 5	10.9794	76.8723	Fertilizer	DAP, Urea, Excelmera 70, Oxygold, Roundup, Potassium Sulphate
Field 6	10.9774	76.8868	Manure	Cow dung and Goat dung
Field 7	10.9801	76.9099	Fertilizer	DAP, Potassium Sulphate, Factum phosphate 20:20:0:13
Field 8	10.9766	76.9269	Manure	Slurry from Bio-Gas Plant
Field 9	10.9783	76.9343	Fertilizer	Potassium Sulphate ,Complex, Excelmera 70, Oxygold, Roundup, Cow dung, Stone Salt
Field 10	10.9813	76.9407	Fertilizer	Potassium Sulphate, DAP, Urea, Calcium Nitrate, Magnesium Sulphate, Round up, Glycine, Oxygoal

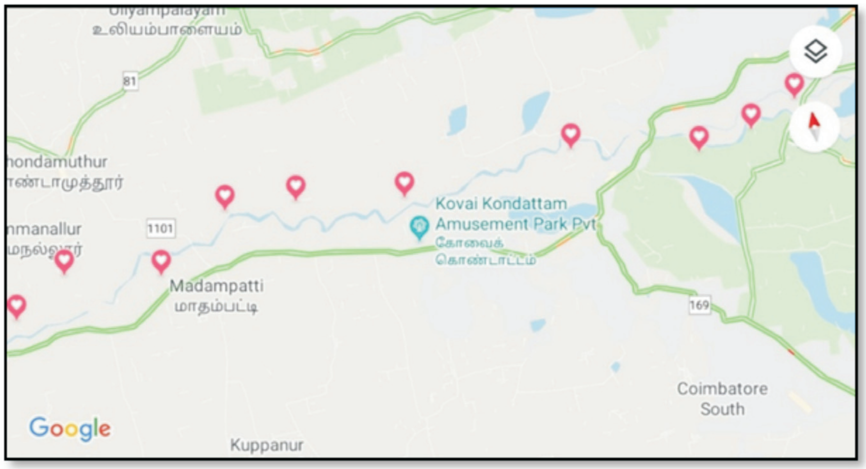

Fig. 2. Sampling Stations for the Site Investigation

examined in laboratory like

a) Physical characteristics
b) Chemical characteristics
c) Mineral characteristic
d) Biological characteristics

Software used for Mapping

The GIS map is developed from the laboratory investigation results of the water samples. The magnitudes and unit of each test vary due to the unique characteristics of the water. The influence of the biomanures and the fertilizers over the aquifers for the different seasons along the Noyyal River is determined using GIS software. It is a geospatial processing programs, and is used primarily to view, edit, create, and analyze geospatial data. It also allows the user to explore data within a data set, symbolize features accordingly, and create maps. The GIS software is ultimately used for the easy interpretation of the laboratory results by weighted overlay method and to obtain the map showing the physical, chemical, mineral and biological properties for the locality from the two sets of data for all sampling stations.

Results and Discussions and Impact Predictions Using Gis Modelling

From the literatures reviewed the site selection is done and the sampling stations is set in such a way

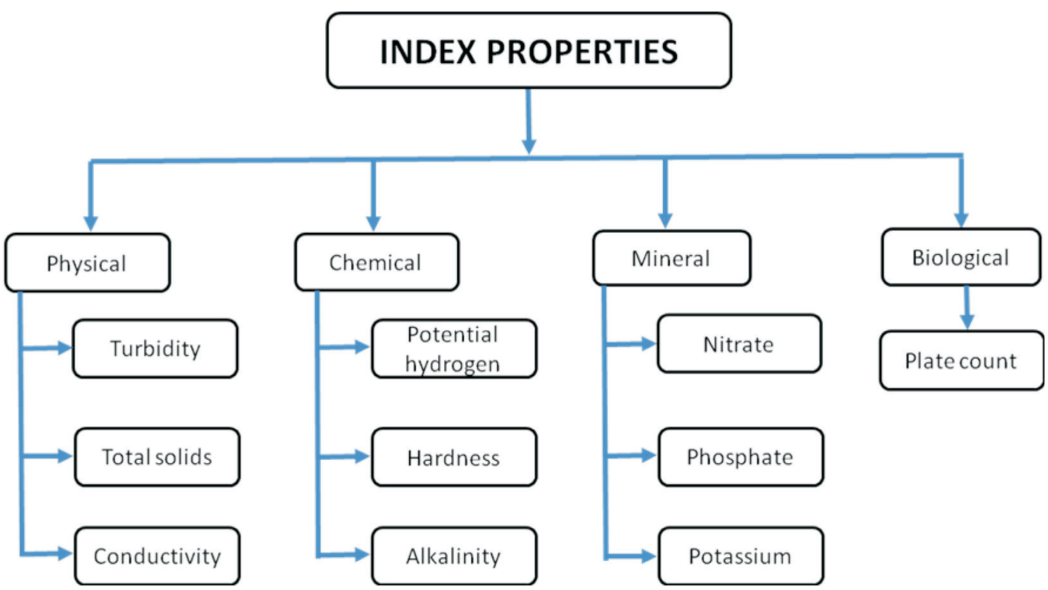

Fig. 3. Index Properties of Water analysed for study

Table 2. Study Area Water Quality Physical and Chemical Parameter Test Results for winter season (SET 1)

S. No.	Location: Field Name	Location: M/F	Turbidity (NTU)	Total solids (ppm)	Electrical conductivity (Cfu/ml)	pH	Hardness (m/cm)	Alkalinity (ppm)	Nitrate (ppm)	Phosphate (ppm)	Potassium (ppm)	Plate count (ppm)
							SET 1					
1	Field 1	F	19.3	50	240	7.46	290	120	0	1.87	9	120
2	Field 2	F	18.8	2000	345	7.31	245	60	0	2.39	22	220
3	Field 3	M	18.6	50	460	7.55	355	90	30	3.38	18	360
4	Field 4	F	18.8	2000	880	7.58	272.5	80	0	2.99	15	250
5	Field 5	F	18.6	2000	320	7.7	160	90	5	2.09	3	350
6	Field 6	M	18.6	2000	510	7.3	505	80	35	3.52	7	560
7	Field 7	F	18.9	2000	500	8.04	37.5	45	20	2.2	3	210
8	Field 8	M	19.1	2000	380	7.88	112.5	100	65	3.89	12	410
9	Field 9	F	18.9	2000	120	7.83	142.5	155	20	2.19	9	240
10	Field 10	F	20.8	50	670	7.44	460	145	10	2.54	18	130

Table 3. Study Area Water Quality Physical and Chemical Parameter Test Results for monsoon season (SET 2)

S. No	Location: Field Name	Location: M/F	Turbidity (NTU)	Total solids (ppm)	Electrical conductivity (m´/cm)	pH	Hardness (ppm)	Alkalinity (ppm)	Nitrate (ppm)	Phosphate (ppm)	Potassium (ppm)	Plate count (Cfu/ml)
						SET 2						
1	Field 1	F	17	2000	275	7.4	567.5	105	0	2.91	14	100
2	Field 2	F	16.9	4000	460	7.3	547.5	40	10	2.86	27	170
3	Field 3	M	17.3	50	540	7.9	187.5	100	45	4.09	19	380
4	Field 4	F	16.7	2500	910	8.02	560	95	10	3.49	22	200
5	Field 5	F	17	4000	475	7.61	275	85	10	2.33	5	370
6	Field 6	M	17.3	2000	575	7.62	72.5	105	40	4.47	18	610
7	Field 7	F	17.1	2500	670	6.59	80	35	25	3.64	14	190
8	Field 8	M	16.7	1000	435	8.13	130	145	70	4.89	13	510
9	Field 9	F	16.8	2000	325	7.66	190	145	30	2.74	16	220
10	Field 10	F	16.4	2000	930	7.42	325	140	15	2.91	8	90

that they are far apart from one another so as to get the wide range of results; the ground water samples are collected for the both seasons and the laboratory tests are carried out to determine the physical, chemical, mineral and biological properties; form the test results obtained, the GIS modelling is carried out and the conclusion is drawn from the comparisons and discussion of the impact prediction maps for the risks analyzed. The Physical and chemical water quality parameter results for winter season (SET 1) are shown in Fig 4 and tabulated in Table 2. The GIS map is developed by obtaining the laboratory investigation results of the water samples. The magnitudes and unit of each test vary due to the unique characteristics of the water.

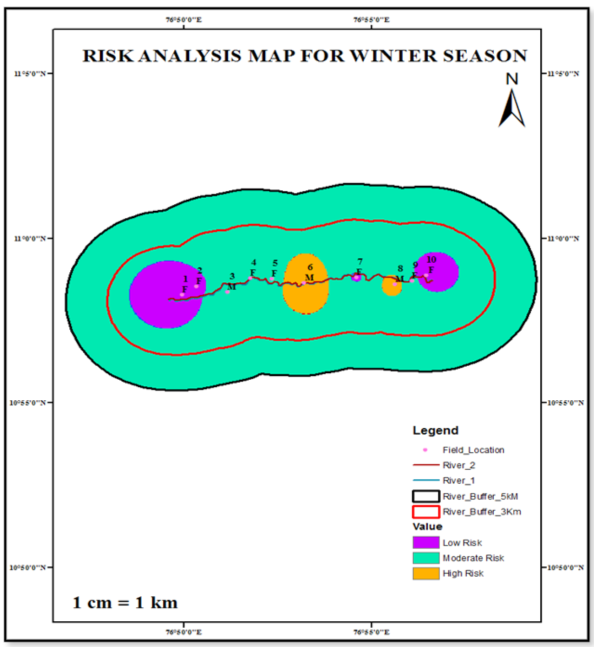

Fig. 4. Risk Analysis Map for Winter Seasons

The map clearly shows the influence factors for the 5 km buffer region along with Noyyal River for all sampling stations during winter and monsoon seasons.

i. Risk Analysis Map for Monsoon Seasons

set 1 means the sample taken during the month of July-September (Winter)
set 2 means the sample taken during the month of October-December (Monsoon)

M – Manure and F – Fertilizer

The risk analysis map of winter season infers that water samples of the fields 1, 2, 7 and 10 (Approximate Radius: Max 1.5 km & Min 250 m) are at low risk, the fields 3, 4, 5 and 9 (Majority of that locality) are at moderate risk and the fields 6 and 8 (Approximate Radius: Max 1.25 km & Min 500 m) are at high risk of getting impacted by the leachate from the agricultural fields.

The risk analysis map of monsoon season infers that water samples of the fields 6, 7 and 8 (Approximate Radius: Max 3 km) are at low risk, the fields 3, 5, 9 and 10 (Majority of that locality) are at moderate risk and the fields 1, 2 and 4 (Approximate Radius: Max 3.5 km & Min 750 m) are at high risk of getting impacted by the leachate from the agricultural fields. The Physical and chemical water quality parameter results for monsoon season (SET 2) are

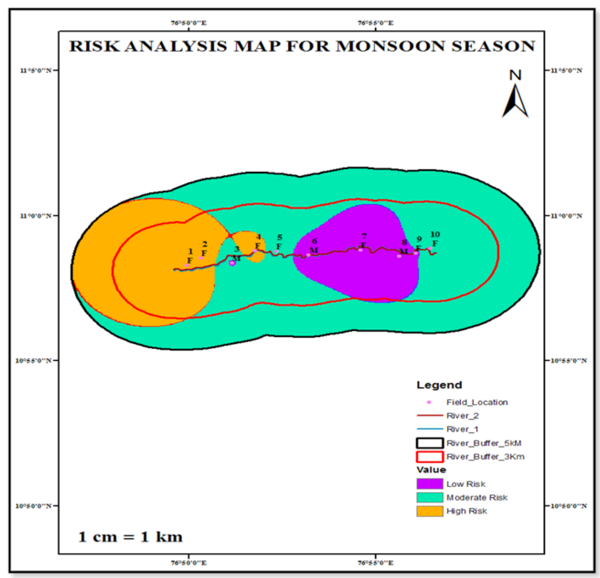

Fig. 5. Risk Analysis Map for Monsoon Seasons

shown in Fig 5 and tabulated in Table 3.

The results inferred that the fertilizers gets infiltrated into the aquifers during the monsoon season and creates high risk to the locality but the bio-manures create low risk. During winter season the impact is vice versa as in Table 4.

Conclusion

Based on the comparisons and discussions of the test results and GIS modelling, the following conclusions are drawn:

From the GIS map obtained it is inferred that the pH, alkalinity, plate count values of fields using bio-manure are less and the fields using fertilizers are

Table 4. Impact Predictions

Seasons	Low Risk (Sampling Stations)	Moderate Risk (Sampling Stations)	High Risk (Sampling Stations)
Winter	1, 2, 7 and 10	3, 4, 5 and 9	6 and 8
Monsoon	6, 7 and 8	3, 5, 9 and 10	1, 2 and 4

high during the winter season; whereas the values of fields using bio-manure are high and the fields using fertilizers are less during the monsoon season. From the hardness and total solids test it is inferred that values of fields using bio-manure are high and the fields using fertilizers are less during the winter season; whereas the values of fields using bio-manure are less and the fields using fertilizers are high during the monsoon season. From the turbidity test it is inferred that all the fields are have high value in winter season; whereas in monsoon season all the fields are having less values. From the nitrate, phosphate, potassium and conductivity tests it is inferred that in winter season all the fields are having less values and in monsoon season all the fields are having high values. To overcome the water supply demand, water treatment for the high water toxic areas are necessity. The sampling points having high turbidity (all Fields) can employ coagulation and sedimentation using alum stones, for the high Nitrates (Field: 8) Reverse osmosis can be carried out and for high total solids (Field: 2, 4, 5, 7) activated carbon filters can be implemented. The overall conclusion of this project is: The safest sampling stations were found to be in the field 3, 5, 7, 9 and 10.

References

Alina Barbulescu, 2020. Assessing Groundwater Vulnerability: DRASTIC and DRASTIC-Like Methods: A Review. *MDPI-Water* 2020, 12, 1356; doi:10.3390/w12051356.

Bettu Sudhakar, 2016. Indian Agriculture- Status, Importance and Role in Economic Development. *IJSR - International Journal of Scientific Research*. 5(8) : ISSN No 2277 – 8179.

George R. Hallberg, 1987. The impacts of agricultural chemicals on ground water quality. *Springer, Geo Journal.* 15: 283-295.

Guidelines for drinking-water quality: fourth edition incorporating the first addendum ISBN 978-92-4-154995-0, World Health Organization 2017.

Indian Standard Drinking Water — Specification (Second Revision), IS 10500: 2012.

Jain, C. K. and Vaid, U. 2018. Assessment of groundwater quality for drinking and irrigation purposes using hydrochemical studies in Nalbari district of Assam India. *Environmental Earth Sciences.* https://doi.org/10.1007/s12665-018-7422-6.

Madhusudhan, L. 2015. Agriculture Role on Indian Economy. *Business and Economics Journal*. 6(4) : 1000176.

Margat, J. and Van der Gun, J. 2013. *Groundwater Around the World: A Geographic Synopsis.* Boca Raton: CRC Press.

Nadimidoddi Leela Sharon and Dr. G. F. Alban Nishanthlalu 2014. A Study on Effects of Chemical Farming on Farmers at Kilkundaiyar Village, Thiruvallur District Tamilnadu. *Indian Journal of Applied Research*. 4. (12. Dec Special Issue), ISSN No-2249-555X.

Raju, A. and Singh, A. 2017. Assessment of groundwater quality and mapping human health risk in central Ganga Alluvial Plain, Northern India. *Environmental Processes.* 4 : 375–397. https://doi.org/10.1007/s40710-017-0232-0.

World Bank 2012. India groundwater: A valuable but diminishing resource.