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IMPACT OF PAMPA IRRIGATION PROJECT ON THE GROUNDWATER QUALITY OF MARAMON REGION ADJACENT TO RIVER PAMPA, SOUTH WEST COAST OF INDIA

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ABSTRACT

The impact of Pampa Irrigation Project canal on the water quality of dugwells adjacent to the Pampa river bank is studied for a period of two years. For many years, groundwater was thought to be protected from contamination by layers of rock and soil that has filters but contaminants do make their way into the groundwater and affect its quality. However, infiltration of water from adjacent rivers and canals affects the physicochemical attributes of ground water. Hence, there is need for concise assessment of the physical and chemical properties of water obtained and distributed from this source. Wastes generated by the thick population resident along the Pampa River banks make this river the most polluted one in Kerala and possibly in India as a whole. While action is being contemplated to reduce the waste disposal at Sabarimala and other locations connected with the pilgrimage, no action is being taken to verify and check the waste disposal from the river banks. The river water level rises abruptly with initiation of South West (SW) monsoon recharging the aquifer along the banks and possibly polluting the drinking water from dug wells. Maramon, one of two stations in studied is also under the influence of an irrigation canal that is opened without any specific time interval also causes contamination of dugwells along with the river born contaminants. Premonsoon and monsoon water samples from river and three dug wells in a transect is studied for its quality during 2014-15 period. Physico-chemical parameters such as pH, conductivity, TDS, nitrate nitrogen, total iron and phosphate and bacteriological parameters such as total coliforms, faecal coliforms and streptococci were analysed.

In general, the monsoons had a clear influence on the dug water table in which SW monsoon increased the maximum level in most of the wells in the study area. Water table fluctuation in Maramon was visibly irregular possibly due to the influence of water that irrigated the area by Pampa Irrigation Project (PIP).pH broadly varied between 6.0 in well water at Maramon during SW monsoon 2014 and7.3 in river water at Thottappuzhasserry without much spatialvariation. In general, both surface and ground water have conductivity below the recommended standards and higher conductivity noticed in river water may be due to stagnation of water due to sand mining. TDS varied from 21mg/l at dugwell two at Thottappuzhasery during Southwest monsoon 2014 to 51mg/l in river water at Maramon during premonsoon 2014. Nitrate nitrogen concentration ranged from 3.38mg/l at dugwell at Thottappuzhasery to 8.23mg/l in river water. Higher values observed in well waters of Maramon irrespective of season might have occurred due to infiltration of contaminated water from PIP canal. Values of total Iron varied from 0.08mg/l at dugwell two at Thottappuzhasery during SW monsoon 2014 to 0.84mg/l in river water at Maramon during premonsoon 2014. The increase in concentration of iron observed in some ground water stations during rainy season could be due to leaching of iron naturally present in lateritic soil facilitated by the unlined nature of wells. Phosphate concentration fluctuated between 0.04mg/l at dugwell one at Thottappuzhasery during pre-monsoon 2014 to 0.54mg/l in river water at Thottappuzhasery during south west monsoon 2015. Spatial and temporal variation was negligible except the high occurrence at well one at Maramon, a highly urbanised point under the influence of PIP canal.

INTRODUCTION

Water quality models take recourse to the behavioural characteristics of receiving bodies of water such as channel and flowcharacteristics, which influence the mixing processes and dispersion ofwaste into surface waters. The three types of mixing processes themselves, viz, vertical, transverse and longitudinal, govern the extent of stratification, the rate at which pollution spreads from one bank to the other, and themovement of wastewater in the downstream, respectively. The thermal and hydraulic conditions of the river have a significant influence on both the biochemical and chemical processes (Gandolfi *et al,* 1996).There is a growing concern about the toxicity, persistence and bioavailability of a wide range of contaminants in groundwater. Once contaminated, it is difficult to restore the quality of ground water. Hence there is a

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need and concern for the protection and management of ground water quality.

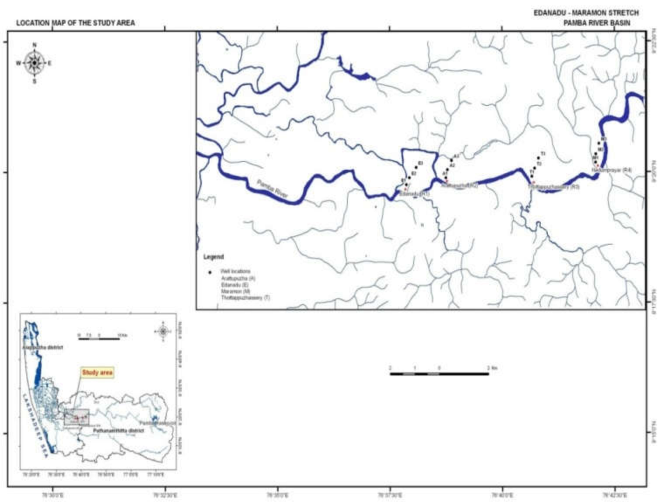
No straight forward reasons can be attributed to the deterioration of water quality, as it is dependent on several parameters. Sources of groundwater contamination can be naturally occurring or anthropogenic. Factors affecting the fate of contaminants include climate, land and water usage, soil and contaminant properties and the prevailing geology and hydrogeology. Pollution attributable to sources such as runoff from roadways, parking lots and other development on riparian areas, coupled with the removal of streamside vegetation, reduces the natural ability of self – purification of water resources. Runoff results from nonpoint source pollution may not be noticeable, but added together, they can have a significant impact on water quality. Anthropogenic factors affecting water quality of a river cause elevated concentrations of nutrient loads in the adjacent ground water also. To deal with point source and non-point source pollution in ground water, a comprehensive scale of analysis and management is required.

The current study attempts to highlight the impact of an adjacent irrigation canal on the well water quality of a region. Field data required to reproduce the hydrodynamic and waterquality aspects and the same is collected for pre- south west monsoon and south west monsoon periods on a monthly basis.

MATERIALS AND METHODS

Study area*:* Two transects such as Thottappuzhasery and Maramon near Chengannur along Pampa river basin were selected for the study. Water samples from the river and three dug well water sample in a transect at 50, 100 and 200m were collected during rainy and non- rainy season of 2014 and 2015. Water level in the wells was monitored between 9AM and 11AM ensuring a time gap of 3hours after pumping. Physico-chemical parameters such as pH, conductivity, TDS, nitrate nitrogen, total iron and phosphate and bacteriological parameters such as total coliforms, faecal coliforms and streptococci were analysed.

Study area



Thottappuzhasery is located 5km away from the Arattupizha, where the houses are built close to the river. Sandy clay and clayey sand up to 15-20ft and 20-35ft sand was generally seen. By the western side of the wetland laterite overlain by soil is exposed in well sections where no sign of alluvial sand was seen. The first well section comprised silt, clayey sand, second well sand up to 30ft with clay, clayey sand and the third well was 30ft deep with black clay and bottomed in fine sand. Recreation by local people and bathing of cattle is common in the riverine station. Alluvium, sandy soil, clayey soil and fine sand were found the well sections of this location.

Maramon is a small town on the Pampa River, opposite to Kozhencherrytown. It is 12 km from the Pathanamthitta district headquarters, the town of Pathanamthitta. The study area fell in Nedumprayar village. The riverbed here is sandy where the channel width is around 150m.The first well is at 0.75km east of Kozhencherybridge. Maramon 12km eastward from Chengannur town is the place where Maramon convention, the biggest spiritual gathering in Asia takes place at Kozhenchery on the banks of Pampa. The Aranmula boat race and Cherukolppuzha Hindu religious convention takes place near Maramon. The riverbed and the water table have been lowered considerably due to sand mining. Dumping of wastes and sewage from Kozhenchery market and town into the river is visible here. Top part of the well section of the first and second wells is sandy while the bottom is ferruginous silty sand or laterite. The third well section is entirely through laterite. Maramon is situated near a canal constructed under Pampa Irrigation Project (PIP).

RESULTS AND DISCUSSION

Water level at Thottappuzhasery has clear influence of seasons where there is increase in water level in all wells during SW monsoon. In Maramon, water level has no visible influence on the monsoon. In Maramon, well section of first and second wells showed that the top part is sand and the bottom is ferruginous silty sand or laterite. The third well section is entirely through laterite. The water table fluctuation was visibly irregular in well one, in well two, though irregular influence of SW monsoon was obvious in well 2 during the second year. This was possibly due to the influence of water that irrigated the area by Pampa Irrigation Project (PIP).

Annual average rainfall of Chengannur region in the study periodis 2873mm. An earlier study on coherent rainfall patterns over India had grouped Kerala as a whole as one cluster as far as south-west monsoon rainfall is concerned (Gadgi l*et al*., 1993).Recent significant trend analysis studies showed that monsoon as a whole is shrinking in India. Though annual rainfall at the Pampa river basin also, showed a substantial shrinkage, this river continually received a higher rainfall compared to that of the State of Kerala, throughout the 1999-2013period (Mayaja and Srinivasa, 2014).Though monsoonal impact is seen on both the stations, irregular water level rise is caused by canal flow at Maramon.

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Water level fluctuation in Thottappuzhasery and Marmon along Pmapa river Bank

Fig. 1. Water level in well 1 at Thottappuzhasery

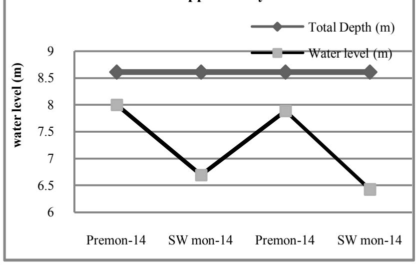


Fig. 2. Water level in well 2 at Thottappuzhasery

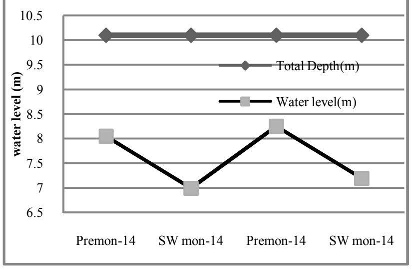


Fig. 3. Water level in well 3 at Thottappuzhasery

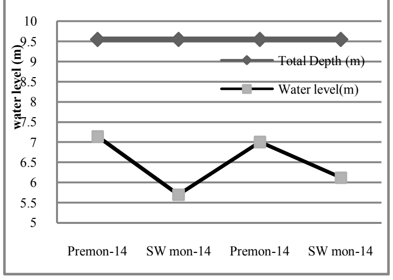


Fig.4. Water level in well 1 at Maramon

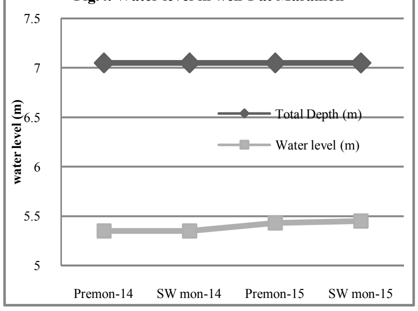


Fig. 5. Water level in well 2 at Maramon

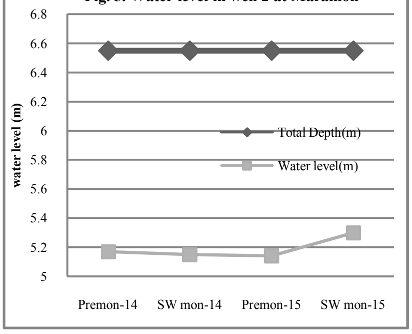
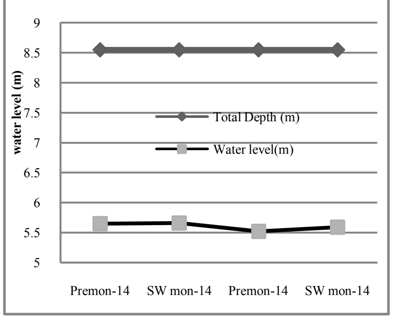


Fig. 6. Water level in well 3 at Maramon



Physicochemical parameters

Fig. 7. Distribution of pH in river and well waters along Pampa river basin

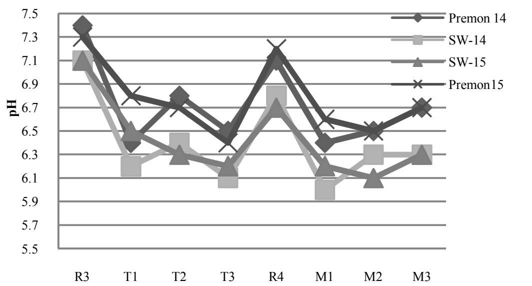


Fig. 8. Distribution of Conductivity in river and well waters along Pampa river basin

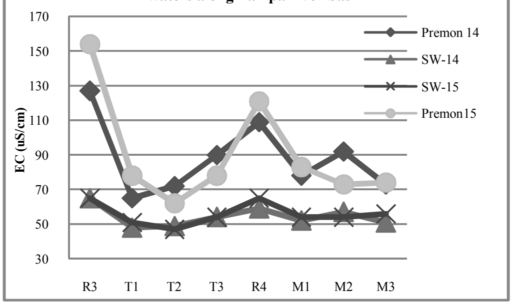


Fig. 9. Distribution of TDS in river and well waters along Pampa river basin

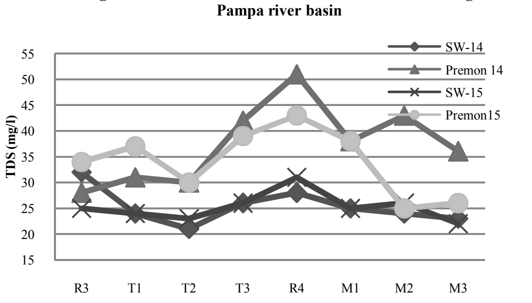


Fig.10. Nitrate nitrogen in river and well waters along Pampa river basin

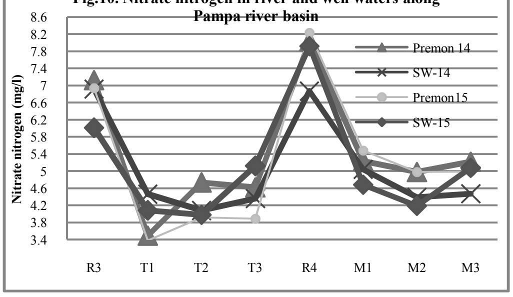


Fig. 11. Distribution of Total Iron in in river and well waters in Pampa river basin

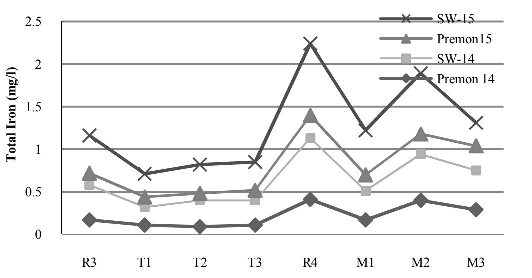
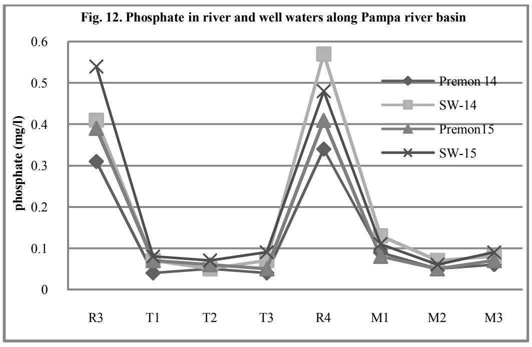


Fig. 12. Phosphate in river and well waters along Pampa river basin



Annual average rainfall of Chengannur region in the study periodis 2873mm. An earlier study on coherent rainfall patterns over India had grouped Kerala as a whole as one cluster as far as south-west monsoon rainfall is concerned (Gadgi l*et al*., 1993).Recent significant trend analysis studies showed that monsoon as a whole is shrinking in India. Though annual rainfall at the Pampa river basin also, showed a substantial shrinkage, this river continually received a higher rainfall compared to that of the State of Kerala, throughout the 1999-2013period (Mayaja and Srinivasa, 2014).Though monsoonal impact is seen on both the stations, irregular water level rise is caused by canal flow at Maramon.

Distribution of pH*:* pH broadly varied between 6.0 at dugwell one at Maramon during Southwest monsoon 2014 and7.3 in river water at Thottappuzhasserry during premonsoon 2015 (fig.7). There is no much difference between the pH values of the stations. Low pH in well water can be attributed to the acidic lateritic soil generally found in midlands of Kerala (Appelo and Postma, 2005) and the organic acids such as fulvic and humic acidsderived from the decay of vegetation and subsequent leaching of plant materials (Thomas *et al*., 2011).The findings of the present study corroborates with the observation of pH range 6.5 to 7.4 in Pampa river by Central Pollution Control Board (MINARS-2010) and that of Jalal and Kumar (2013).

Distribution of Conductivity: Conductivity varied from 47µmhos/cm at dugwell two at Thottappuzhasery during Southwest monsoon 2014 to 154µmhos/cm in river water at Maramon during premonsoon 2014 (fig.8).In general, the study indicates that both surface and ground water in the study area have conductivity below the recommended standards for drinking water. Comparatively higher conductivity values noticed in river water during premonsoon periods may be due to stagnation of water due to sand mining, low quantum of water and minerals coming through drainage and paddy fields. Conductivity values in the range of 70 - 1437 µmhos/cm is reported by Central Pollution Control Board (MINARS-2010) from rivers of Kerala. The values are similar to that reported from the south of Karuvatta (30 to 670µmhos/cm) by CGWB (2014) and that (43-57µmhos/cm) by Central Pollution Control Board (MINARS-2010) in Alappuzha district.

Distribution of TDS: TDS varied from 21mg/l at dugwell two at Thottappuzhasery during Southwest monsoon 2014 to 51mg/l in river water at Maramon during premonsoon 2014 (fig.9).TDS represents the sum of concentrations of all dissolved constituents in a water sample. The total ground water samples of study area are registered with 100% belonging to fresh type (TDS<1000 mg/L) in both pre-monsoon and post-monsoon seasons as per TDS classification given by Fetter (1990).TDS values in the range of 781to 1547 mg/l are reported from groundwater of Palar river bank in Tamilnadu by Tamilarasi *et al (2015*). ***Distribution of nitrate nitrogen:*** Nitrate nitrogen concentration ranged from 3.38mg/l at dugwell two at Thottappuzhasery during Southwest monsoon 2015 to 8.23mg/l in river water at Maramon during pre-monsoon 2015 (fig.10).Compared to river water, lower nitrate values were observed in most of the well waters during monsoon season and this could be attributed to dilution effect of rain water.Highervalues observed in well waters of Maramon irrespective of season might have occurred due to infiltration of contaminated water from PIP canal. Nitrate contamination of groundwater is commonly associated with the application of fertilizers which is difficult to remove from source water and in excess make the water unhealthy for humans and/or animals to drink. The presence of high or low water tables, the amount of rainwater, the presence of organic material and certain physicochemical properties are important determinants on the fate of nitrate in soil (Fewtrell, 2004). Using the threshold of 3.0mg/l, the distribution of nitrate in the current study should be viewed with evidence of anthropogenic contamination. In general, in groundwater the frequency of violations increased as depth to water table decreased. However, the current values are much higher than that of an earlier study by CPCB from Pampa river at Chengannur region which reported nitrate concentration @ 0.98-2.4mg/l (MINARS-2010).

Distribution of total Iron: Values of total Iron varied from 0.08mg/l at dugwell two at Thottappuzhasery during SW monsoon 2014 to 0.84mg/l in river water at Maramon during premonsoon 2014 (fig.11).Rainwater as it infiltrates the soil and underlying geologic formations dissolves iron, causing it to seep into aquifers that serve as sources of ground water. The presence of iron in ground water is a direct result of its natural existence in underground rock formations and precipitation water that infiltrates through these formations. Total Iron content in the range of 0.1 to 14.0ppm was reported in a study done by CGWB (2014) from Kuttanad. Mean iron concentration during different seasons showed significant difference and lower concentration was observed during summer whereas, monsoon concentrations were higher. The increase in concentration of iron observed in some ground water stations during rainy season could be due to leaching of iron naturally present in lateritic soil facilitated by the unlined nature of wells. Iron concentration in the well water samples fall below the permissible WHO standard of 0.3mg/l (WHO, 1993). The river water crossed this threshold particularly in rainy season. However, all values in the study area fall within the standard (1.0mg/l) prescribed by BIS (1991).

Distribution of phosphate: phosphate concentration fluctuated between 0.04mg/l at dugwell one at Thottappuzhasery during pre-monsoon 2014 to 0.54mg/l in river water at Thottappuzhasery during south west monsoon 2015 (fig. 5).Anthropogenic sources of phosphate in groundwater include domestic sewage, animal wastes, agricultural effluents and industrial effluents. Phosphate in natural water mostly ranges between 0.005 and 0.020 mg/l (Chapman and Kimstach, 1992). For this range, phosphate values of all the samples in the study area are comparatively higherirrespective of seasons. Spatial and temporal variation was negligible except the high occurrence at well one at Maramon, a highly urbanised point under the influence of PIP canal. Phosphate values in the range 0.12 -1.56mg/l and 0.4-7.0mg/l were reported from river Ganga respectively by Khatoon *et al (2013*) and Chattopadhyay *et al (1984*).The general enrichment of phosphate in monsoon period reveals that leaching through soil has a strong bearing on the nutrient levels in groundwater (Babu *et al*., 2007).

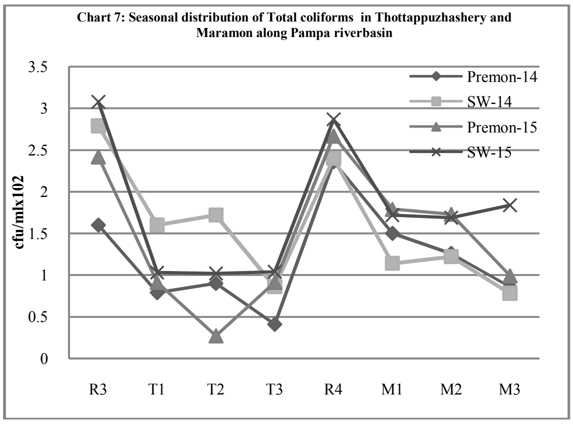


Chart 7: Seasonal distribution of Total coliforms in Thottappuzhashery and Maramon along Pampa riverbasin

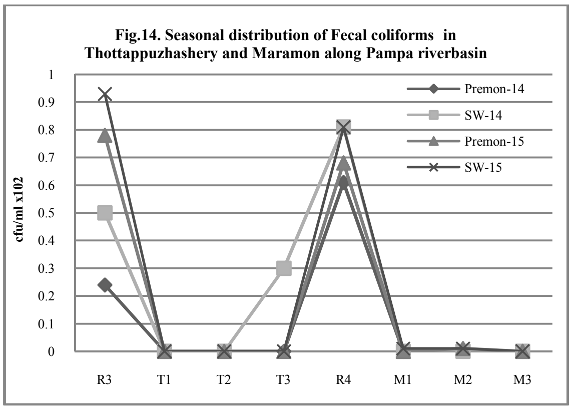


Fig.14. Seasonal distribution of Fecal coliforms in Thottappuzhashery and Maramon along Pampa riverbasin

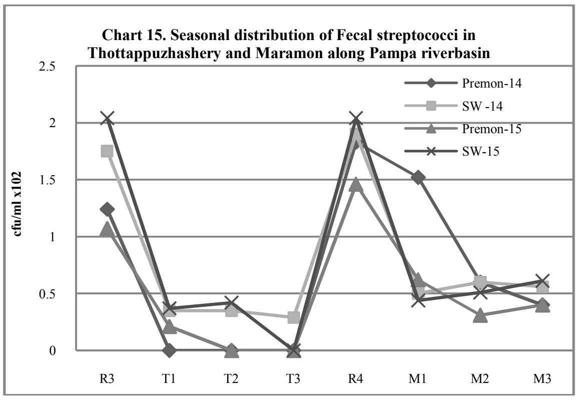


Chart 15. Seasonal distribution of Fecal streptococci in Thottappuzhashery and Maramon along Pampa riverbasin

Distribution of bacterial parameters: The maximum total coliform contamination was observed from the river station at Thottappuzhasery during monsoon season (fig.13). Theminimum value was recorded from well two at Thottappuzhasery. A comparison of data of revealed that there was one fold increase in concentrations of indicator organisms during SW monsoon season in well waters of Tottappuzhasery irrespective of their proximity to the river. However, monsoonal influence was not considerable in Maramon where similar or slightly higher coliform count during premonsoon season was recorded. This could be possibly from the infiltration of contaminated water from PIP canal. Higher densities of indicator organisms was observed in wells close to river stations possibly due to more infiltration from river, percolation as well as seepage of domestic sewage through the soil. Microbial Source Tracking (MST) is a way of identifying the source of microorganisms in a watershed. By determining the pollutant source, an assessment can be made on the risk of pathogen contamination. Though high total coliform counts were noticed, faecal contamination was not visible in well water. Pampa river on the contrary has high contamination of faecal matter irrespective of season (fig. 14). During monsoon season, faecal Streptococci (FS) was enumerated from well waters of both the stations. At Thottappuzhasery, FS was not detected during premonsoonwhile samples from Maramon recorded them even during non-rainy period. This indicates the infiltration of bacterial contaminants through PIP canal water.

Apart from chemical contaminants, coliform bacteria have been reported to move through soil from 0.9 to 456m depending on the soil type (Gerba *et al*., 1975*)*. Coliforms from septic tank effluent get transported at rates between 10^2 and 10^6 cells per day through 60-cm packed loamy sand soil columns subjected to unsaturated flow conditions over a period of 200 days, which represented a 92% removal rate (Ziebell, 1975). Infiltration basins over loamy sand were shown to transport as much as 100 times more faecal coliforms to groundwater following rainfall than during dry spells (Bitton and Gerba*,* 1984*)*. In Scotland, Benton *et al (1989*) reported that private supplies caused 21 out of 57 waterborne disease outbreaks between 1945 and 1987 (37%).

It is possible that pathogens that are present at low levels in water multiply when they are exposed to favourable environmental conditions or available nutrients. In fact, it has been shown that the levels of members of several genera of pathogenic bacteria decrease only slightly during 100 days in groundwater alone (Filip *et al*., 1988) and several studies have shown that sediments serve as reservoirs for faecal pathogens (Burton *et al*., 1987; Crabill *et al*., 1998, Packiaraj, D., 2009, Deleep Packiaraj, 2010, Shaniya *et al, 2018*).

CONCLUSION

Wells remain the main source of water for domestic use in Kerala with an average of 250 wells per sq. km. For many years, groundwater was thought to be protected from contamination by layers of rock and soil that has filters but contaminants do make their way into the groundwater and affect its quality. Since groundwater moves through rocks and sub surfaces, it has a lot of opportunities to dissolve substances as it moves. This property in turn affects the physicochemical attributes of water from this source. Hence, there is need for concise assessment of the physical and chemical properties of water obtained and distributed from this source. For that reason, groundwater will often have more dissolved substances than surface water will. These wastes, coupled with that generated by the thick population resident along the Pampa River banks makes this river the most polluted one in Kerala and possibly in India as a whole. While action is being contemplated to reduce the waste disposal at Sabarimala and other locations connected with the pilgrimage, no action is being taken to verify and check the waste disposal from the river banks. The river water level rises abruptly with initiation of South West (SW) monsoon recharging the aquifer along the banks and possibly polluting the drinking water from dug wells. Maramon, one of two stations in studied is also under the influence of an irrigation canal that is opened without any specific time interval also causes contamination of dugwells along with the river born contaminants during monsoon period.

In general, the monsoons had a clear influence on the dug water table in which SW monsoon increased the maximum level in most of the wells in the study area. However, at Maramon, the PIP canal seems to have a controlling role in the water level. Water quality of wells in Maramon in terms of indicator bacteria and nitrate content are controlled by the infiltrating PIP canal water.

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