

## Analysis of the Drinking Water Quality and Socioeconomic Status of the Community Living in Poonthura, Thiruvananthapuram, India

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### ABSTRACT

Environmental pollution and water quality are essential parameters that greatly influence the well-being of society. Poonthura is one of the highly polluted areas in Thiruvananthapuram, Kerala. No reports were available on the drinking water quality and the socio-economic status of the people in this area. The socio-economic survey conducted as part of the current study shows that improper waste management and lack of awareness among the people are significant problems for pollution in this area. The physicochemical and microbiological characterisation of groundwater in this area shows that over 90% of the groundwater is not potable. Bacteriological analysis show that 75% of the wells were contaminated with coliforms. Bacterial contamination may pose a threat to public health. The physicochemical analysis shows that nitrate level is very high in some samples analysed, and the reported values were above the permissible limits of WHO standards for drinking water. This study recommends an urgent need for implementing proper waste management and continuous monitoring of groundwater quality in the Poonthura area.

**Key words:** Physicochemical characterization, well water, socio-economic survey

### INTRODUCTION

Drinking water quality is fundamental to public health. Despite the technological advancements in recent decades, developing countries are still in the grip of a grave problem; inaccessibility to good quality drinking water (Levallois et al. 2019). Where 785 million people have no access to essential drinking-water services, 144 million individuals are dependent on surface water. This issue demands urgent attention, as scarcity of potable water will affect half of the world's population by 2025 (WHO/ UNCEF nd.). The situation in India is no better. Poor management of the water resources, lack of coordination of the supply and demand, climate change, etc., would contribute to a severe water crisis in the country. While access to improved water supply has expanded significantly over the past two decades, most of the water sources in India are heavily polluted due to the discharge of untreated sewage and human excreta into the water bodies (Maria 2003). Not only the surface water source but

also the groundwater is polluted (Saptarshi Dutta 2018). In Kerala, the groundwater caters to 80% of the rural and 50% of the urban communities for their drinking and domestic needs (Ananth et al. 2018, Megha et al. 2015). A recent study analysed the water quality and pollution level of 44 rivers in Kerala from 2009 to 2017 and found that all the rivers were polluted (Chattopadhyay and Harilal 2017). This includes the Karamana river, which meets the water supply needs of the Thiruvananthapuram corporation. Karamana river is highly polluted, especially in the Poonthura region, where the river joins with Parvathy Puthanar. Environmental pollution considerably impacts the quality of drinking water, which may cause a range of chronic diseases like cancer, cardiovascular disease, adverse reproductive outcomes, and effects on children's health (Villanueva et al. 2014). Few studies have been conducted to characterise the pollution status of heavy metals in this estuary (Arunkumar et al. 2010). However, there are no reports published on the groundwater quality of the Poonthura region.

Contaminated water can also be a repository of several pathogenic microorganisms (Pandey et al. 2014). Kerala faces the threat of frequent outbreaks of water-borne diseases such as cholera and hepatitis and vector-borne diseases such as malaria and dengue (Megha et al. 2015). Hence, analysis of the drinking water quality and the socio-economic status of the people living in this area was the need of the hour to understand the underlying reasons for water pollution and the different ways this affects the community structure. This will help in alleviating the health hazards associated with the consumption of water that is unsafe to drink.

## MATERIALS AND METHODS

### Study area

Thiruvananthapuram city is along the southwest coast of India. It spreads over 250 Km<sup>2</sup> and houses about 7.4 lakh people (2011 censuses). Poonthura is a suburb of Thiruvananthapuram city. Poonthura estuary is one of the most polluted estuaries in Thiruvananthapuram city. It is located on the southwest coast of India (latitude between 8°25' and 8°3'N and longitude 76°55' and 77°00'E). Parvathy Puthanar, the most severely polluted canal in the city, which connects the Velilake and the Poonthura estuary, joins with the karamana river at Moonnattumukku. The primary reason for the pollution is the sewage carried by the Parvathyputhanar canal spilt from the sewage farm situated in the Poonthura area.

### Socio-economic survey

The socio-economic survey was done on 100 families living on the banks of the Karamana river. This survey included gender, age, occupation, waste generation and disposal methods, sanitation facilities, land usage, river utilisation, etc.

### Sample collection

Water samples were collected from 97 wells in the Poonthura area. Among these, 17 were from bore wells, and the remaining 80 were from open wells. Samples were also collected from the river from two locations in this area. The control sample used was distilled water. The samples were collected in sterile bottles per standard methods, and these were

analysed using standard methods for physicochemical properties (Rice et al. 2012). For bacteriological analysis, samples were collected in sterile tubes and immediately transferred to the icebox. The samples were transported to the laboratory within 3 hours of collection and were analysed for various parameters per standard methods (Rice et al. 2012). The results were compared with the drinking water standards specified by WHO (WHO 2012) and Indian Standards (BIS 2012).

### Physicochemical characterization of water

The pH of the samples was analysed using a pH meter (Systronics, India). Electrical conductivity (EC) and TDS were analysed using a TDS meter (Digital TDS Meter 661 (Portable), Electronic India). Dissolved oxygen was analysed by the modified Winkler method (Pomeroy and Kirschman. 1945). Nitrate, Nitrite, Ammonia (Product ID W 25530), Chloride, Fluoride and residual Chlorine (Product ID W25540) were analysed using a water analysis kit as per manufacturer instruction (Nice Chemicals, Ernakulam, Cochin, Kerala).

### Faecal coliform analysis

The samples were kept in an icebox for bacterial analysis, and analysis was carried out within 3hrs. Bacteriological analysis was carried out using the Membrane filtration technique (Brian Forster and Catalina Arango Pinedo. 2015) and confirmed using Eosin Methylene Blue (EMB) agar test.

## RESULTS

### Socio-economic status of the people living in Poonthura

Riverside populations are from an impoverished socio-economic background. All the age groups are living in this area. The age group of 30 to 50 years is more in this area (Table 1). However, the children of age group 1 to 5 years are less, showing the migration of the new family to other parts of the city. The reason for migration is new employment opportunities in other areas and the prevalence of pollution in this area. Among the study subjects, more than 70% population is labour workers, only 5% are government employees, and 10% have a business.

Table 1. Socioeconomic survey of people in Poonthura

S.No	Criteria	%
1.	Solid waste segregation	10
2.	Biodegradable waste	
	Composting	7
	House premises	53
	River	40
3.	Nonbiodegradable waste	
	Burning	80
	River	20
4.	Electronic waste	
	House premises	40
	River	50
	Others	10
5.	Disease prevalence (Past six months)	
	Dengue	30
	Jaundice	2
	Diarrhoea	20
	Allergic Asthma	30
6.	Occupation	
	Labour workers	70
	Farmers	10
	Government Employees	5
	Own Business	10
	Others	5
7.	Age group	
	1-5	2
	6-15	7
	16-30	26
	31-60	36
	Above 60	29

Less than 10% are farmers.

Plastic waste burning and disposal in the river and household areas are common problems. Only 10% population is doing solid waste segregation. 7% population is using it for composting, and 53% are discarding it on household premises. 40% are discarded in the river. 80% population is burning nonbiodegradable waste, mainly plastic. 20% of nonbiodegradable waste is dumped in the river. 40% of electronic waste is disposed of in residential areas, and 50% is dumped in the river. In some areas, they are selling plastic waste. Poultry waste from other areas was also dumped in the river and

associated areas. There is no significant prevalence of any diseases. However, the occurrence of vector-borne diseases such as Dengue fever and water-borne diseases such as diarrhoea are reported in this area. One of the noticeable things is the occurrence of allergic asthma in 15% population studied (Table 1).

#### Physicochemical and biological characterization of water samples indicates that the water is heavily polluted.

We observed that among 97 well-water samples analysed, only eight samples met the criteria of drinking water quality as per the WHO guidelines. Drinking water with a pH of 6.5 to 8.5 is generally considered satisfactory. In this study, pH ranges between 3 and 9. Among the 97 samples analysed, forty-one samples show a pH below 6.5, and only one shows a pH above 8.5. The pH of the Control sample was 6.5, and that of the river samples was 6. The remaining samples had pH within the safe limit of 6.5 to 8.5 standard set by the WHO (Fig.1a). In the present study, the range of TDS of analysed water samples varied between 63 to 1300 mg/l. However, a TDS value of 3600 mg/l was recorded for the sample that had pH 9. 75% of the samples showed a TDS value well within the limit (Fig.1b). The permissible limit for electrical conductivity (EC) is  $250 \mu\text{S cm}^{-1}$ , and the maximum limit is  $1000 \mu\text{S cm}^{-1}$ . EC of the collected samples ranged between 60 and  $630 \mu\text{S cm}^{-1}$ . Twenty-two samples showed the EC value within the desirable limit. EC of the other samples was within the maximum limit proposed by WHO (Fig.1c). The dissolved oxygen level varied from 1.2 to 9 mg/l. The permissible limit of dissolved oxygen in drinking water is 5 mg/l. It can range from 1 to 20 mg/l in drinking water (Fig.1d). Nitrate and Nitrite are naturally occurring ions that are part of the nitrogen cycle. The permissible limit of nitrite is 1 mg/l. Only three samples showed nitrite above this level (Fig.1e). The permissible limit of nitrate is 45 mg/l. More than 80% of the well-water samples were under the permissible limit. However, in 20% of the samples, the nitrate level was very high (Fig.1f). Ammonia content was well within the limit except for two samples, and for nine samples, it was above the upper limit, i.e. 1.5 mg/l (Fig.1g). The chloride content of the studied water samples was within the permissible limit of 250 mg/l except for three samples

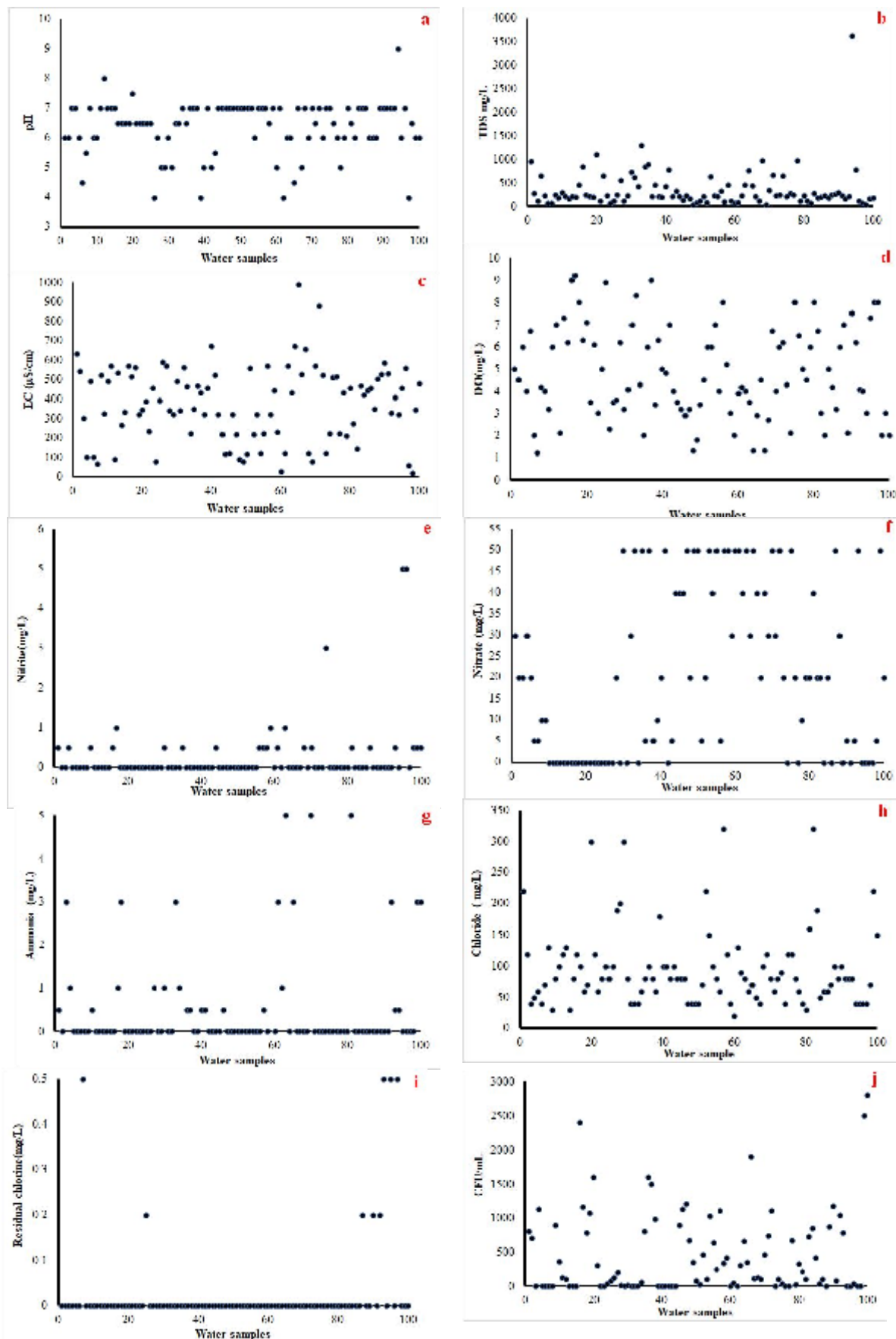


Figure 1. Physiochemical and bacteriological analysis of well water and river water samples. (a) pH, (b) Total Dissolved Solids, (c) Analysis of Electrical Conductivity (EC), (d) Dissolved oxygen, (e) Nitrite, (f) Nitrate, (g) Ammonia, (h) Chloride, (i), Residual Chlorine (j) Faecal coliform count. Sample number 1-97 is healthy water, 98 and 99 are river water, and the 100th sample is control

(Fig.1h). We could detect fluoride in well water in this area. Residual chlorine was within the range of WHO standard (0.2 mg /l) except for four samples. Nevertheless, these samples were below the upper limit (5 mg/l) (Fig.1i).

The faecal coliform bacterium in the water indicates pollution from human and animal faecal matter. Faecal coliform analysis indicated that more than 75% of the water samples were not potable (Fig.1j). Only in 25% of samples we could not detect *E. coli*.

## DISCUSSION

Poonthura is one of the highly polluted regions in Thiruvanthapuram city. Analysis of the socio-economic status is essential in understanding the reason for pollution and its impact on society. In this study, we have analysed the socio-economic status and drinking water quality of the Poonthura area. We can see that the pollution in Poonthura is mainly due to improper waste management and a lack of awareness among the population. Discharging untreated sewage and greywater from the houses near the river Karamana is one of the main reasons for water contamination in this area. This also impacts drinking water quality since the leachates can contaminate nearby wells. The Parvathy Puthanar canal's sewage also contributes to this area's pollution. Burning plastic is one of the major problems in this area, which may be the reason for the prevalence of allergic asthma (Verma et al. 2016). We could see a reduction in the population of children within the age of five in this area. This may be because of the migration of the younger generation to other parts of the city, mainly due to the pollution and to get better jobs. The people living in this area are mainly labourers. Owing to severe pollution, the residents cannot use the river water. Reducing pollution and reviving the rivers are of utmost importance in utilising these rivers in the current era of water scarcity (Borthakur et al. 2016). Even though there is no major disease outbreak in this area, vector-borne diseases and allergic asthma are reported. Environmental pollution and improper solid waste management are crucial in climate change. Plastic burning also affects the environment (North and Halden 2013). There is an urgent need to provide

general awareness among the residents and to implement proper waste management in the Poonthura area. This will help to reduce the pollution rate.

There is no report published on the groundwater quality of the Poonthura area. There are only a few reports on the physicochemical characterisation of the Karamana river water and Poonthura estuary (Beslin 2014, Chattopadhyay and Harilal 2017). These data show that the river is highly polluted in Thiruvallam and Poonthura areas. We have analysed the groundwater quality of the wells in this area. Our study reports that among the ninety-seven samples analysed, only eight samples meet the drinking water standards as per the WHO guidelines. 75% of the samples show a high level of coliform bacteria. Therefore, the findings of this study indicate that majority of wells in the study area are severely contaminated with coliform bacteria. There are some wells with a pH below 6.5 that may be attributed to the discharge of acidic products into this source by domestic activities. The acidic pH can be neutralised by adding a blend of calcite and magnesium oxidise (University of Massachusetts nd.). We observed a high level of nitrate in the samples collected from the wells, which were located near the river basin. Sources of nitrate can enter the well through septic systems, fertilisers, animal feedlots, food processing waste, etc. This can cause severe diseases, cancer and blue baby syndrome (Knobeloch et al. 2000). In some of the samples, TDS levels were also observed to be high.

The study revealed the pollution of open wells and bore wells in the study area with a high content of nitrate. Also, most open wells are contaminated with total coliforms and faecal coliforms. The groundwater sources in the study area are suitable for irrigation purposes. The study results vividly point out the need for proper treatment of groundwater for drinking and domestic purposes. To avoid bacterial contamination, wells should be constructed at a distance of 7.5 to 15 m away from the septic tank. It is suggested to conduct periodic well water quality monitoring and awareness programs among the residents in the study area. Proper groundwater management measures are necessary to restore declining water quality. This study shows that pollution affected the groundwater

quality of wells and the socio-economic status of the people living in Poonthura. Proper waste management and continuous monitoring of the well water are the need of the hour to reduce pollution and improve water quality and socioeconomic status in this area.

## CONCLUSIONS

This study indicates that pollution affected the groundwater quality of wells and the socio-economic status of the people living in Poonthura. Improper waste management and lack of awareness among the community is the major reason for pollution in the Poonthura area. This also emphasises the importance of waste management in pollution control, which is a serious environmental threat and a major contributor to climate change. Further experiments are required to analyse the heavy metal pollution in these wells.

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## REFERENCES

- Ananth, M., Rajesh, R., Amjith, R., AL, A., Valampampil, M.J., Harikrishnan, M., Resmi, M.S., Sreekanth, K.B., Sara, V., Sethulekshmi, S. and Prasannakumar, V. 2018. Contamination of household open wells in an urban area of Trivandrum, Kerala State, India: a spatial analysis of health risk using geographic information system. *Environmental Health Insights*, 12, 1178630218806892.
- Arunkumar, K.S., Joseph, S. and Thomas, J. 2010. Heavy metal concentration in the coastal wetlands of Thiruvananthapuram district, southern India. *Journal of Environmental Science & Engineering*, 52, 131-136.
- Beslin, L.G. 2014. Water and Sediment Quality Assessment of Poonthura Backwater on the Southwest Coast of India. *American Journal of Marine Science*, 2, 43-46.
- Borthakur, A. and Singh, P. 2016. India's lost rivers and rivulets. *Energy, Ecology and Environment*, 1, 310-314.
- Forster, B. and Pinedo, C.A. 2015. Bacteriological Examination of Waters: Membrane Filtration Protocol. American Society for Microbiology. <https://www.asmscience.org/content/education/protocol/protocol.3982#> (Accessed: 19 January 2021).
- Bureau of Indian Standards. 2012. IS 10500:2012, Standard, I., 2012. Drinking Water Specification (2<sup>nd</sup> revision). IS, 10500, 2012.
- Chattopadhyay, S. and Harilal, K.N. 2017. River restoration in Kerala: Developing a co-evolutionary Framework and river restoration action plan for Thiruvananthapuram city. Centre for Development Studies Thiruvananthapuram, India.
- Knobeloch, L., Salna, B., Hogan, A., Postle, J. and Anderson, H. 2000. Blue babies and nitrate-contaminated well water. *Environmental health perspectives*, 108, 675-678.
- Levallois, P. and Villanueva, C.M. 2019. Drinking water quality and human health: an editorial. *International Journal of Environmental Research and Public Health*, 16(4), 631.
- Maria, A. 2003. The costs of water pollution in India. In: The Conference on Market Development of Water & Waste Technologies through Environmental Economics, 30-1.
- Megha, P.U., Kavya, P., Murugan, S. and Harikumar, P.S. 2015. Sanitation mapping of groundwater contamination in a rural village of India. *Journal of Environmental Protection*, 6, 34.
- North, E.J. and Halden, R.U. 2013. Plastics and environmental health: the road ahead. *Reviews on Environmental Health*, 28, 1-8.
- Pandey, P.K., Kass, P.H., Soupir, M.L., Biswas, S. and Singh, V.P. 2014. Contamination of water resources by pathogenic bacteria. *Amb Express*, 4, 1-16.
- Pomeroy, R. and Kirschman, H.D. 1945. Determination of dissolved oxygen. Proposed modification of the Winkler Method. *Industrial and Engineering Chemistry Analytical Edition*, 17(11), 715-716.
- Rao, B.V. 2011. Physicochemical analysis of selected ground water samples of Vijayawada rural and urban in Krishna district, Andhra Pradesh, India. *International Journal of Environmental Sciences*, 2, 710-714.
- Rice, E.W. (Ed). 2012. Standard methods for the examination of water and wastewater (Vol. 10). Washington, DC: American Public Health Association.
- Dutta, S. and Bhaskar, S. 2018. Surface and groundwater pollution are pushing India towards a water crisis. <https://swachhindia.ndtv.com/world-water-day-2018-surface-and-groundwater-pollution-are-pushing-india-towards-an-irreversible-water-crisis-17882/> (accessed on 15 April 2020).
- University of Massachusetts. nd. pH – Acidity of Private Drinking Water Wells. <https://ag.umass.edu/cafe/factsheets/ph-acidity-of-private-drinking-water-wells>.
- Verma, R., Vinoda, K.S., Papireddy, M. and Gowda, A.N.S., 2016. Toxic pollutants from plastic waste-a review. *Procedia Environmental Sciences*, 35, 701-708.
- Verma, R., Vinoda, K.S., Papireddy, M. and Gowda, A.N.S. 2016. Toxic pollutants from plastic waste-a review. *Procedia Environmental Sciences*, 35, 701-708.

- Villanueva, C.M., Kogevinas, M., Cordier, S., Templeton, M.R., Vermeulen, R., Nuckols, J.R., Nieuwenhuijsen, M.J. and Levallois, P. 2014. Assessing exposure and health consequences of chemicals in drinking water: current state of knowledge and research needs. *Environmental Health Perspectives*, 122(3), 213-221.
- WHO, U. 2012. Progress on drinking water and sanitation. Joint Monitoring Programme for water supply and sanitation (JMP)
- WHO/UNICEF. nd. Drinking Water. <https://www.who.int/news-room/fact-sheets/detail/drinking-water> (accessed on 11 February 2019)

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