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WATER QUALITY AND GASTROINTESTINAL DISEASE, PHYSIOLOGICAL IMPACT ON GUT FUNCTION

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ABSTRACT

Objectives

This study aims to assess the impact of water quality on gastrointestinal diseases and the physiological effects on gut function, with a focus on rural and urban populations in Pakistan.

Materials and Methods

Cross-sectional study was carried out at more than one place in Pakistan, water samples were collected and tested for microbial and chemical quality. Gut symptoms were assessed in study participants, and fecal samples collected to assess microbiota profile and inflammation.

Results

The findings showed high levels of water pollution by pathogens which has enhanced the incidence of gastrointestinal diseases particularly in the rural population. It was further observed that the levels of chemical in the urban area were significantly high which had negative impact on the dysbiosis and gut health. A positive correlation between water quality and incidences of diarrhoeal disorders, flatulence and other stomach upsets was established by the study.

Conclusion

The study underscores the critical need for improved water treatment and monitoring systems to reduce waterborne diseases and safeguard gut health**.**

Keywords: Water quality, gastrointestinal diseases, gut health, microbial contamination, Pakistan, dysbiosis.

INTRODUCTION

The importance of water quality cannot be overemphasised because water impacts all aspects of the physiological and pathological health of man, especially in the gastrointestinal tract (1). The gut is an

intricately organised structure and functions as the surficial contact for the body's internal environment. There has in recent past been increasing concern towards understanding the impact of the environment, like water, on the health of the guts and, consequently, gastrointestinal diseases. Interactions between water quality and intestinal microbiota, immune system, and intestinal barrier function determine the prevalence and severity of GI disorders. Studies carried out in aquatic ecosystems, especially the effects of water quality on gut health, offer insight value that can be applied to human health.

The impactInternational health experts well understand impact of water quality on human health because water consumed by individuals directly influences the level of gut microbiota, which is vital for gut health. Scientific research has also shown how toxicants or adjuvants in water change the local flora of the gut, making it more susceptible to infections and chronic inflammation (1, 2). For example, microbial imbalance shown in functional bowel disorders like irritable bowel syndrome (IBS) confirms that even water-borne agents affect gut function and disease development significantly (2). Furthermore, due to chronic inflammation and a reduced gut barrier, which is described in inflammatory bowel diseases (IBD), the importance of the composition of the intestinal microbiota and the consequences of poor water quality were also highlighted (3).

The gut microbiota, recognized as a critical effector of gut health, is generally known to be an exquisitely sensitive aspect of the body's microenvironment. Studying the gut microbial communities in aquaculture organisms has shown that these communities are highly sensitive to fluctuations in water quality and have profound effects on the intestine and immune system (4). Such effects concern human health, given that they extend water quality implications to the regulation of gut microbiota and, therefore, gut health. The involvement of microbiomes in homeostasis is particularly pronounced in aquatic vertebrates, where they also perform immunological and nutritional functions (5). Likewise, the human body requires a well-stabilized gut microbiota for the proper functioning of the physiological and immune systems.

The mutual interaction between gut-associated immune and microbial processes also stresses the significance of water quality. Some of the pathogenic microbes or toxins in the water can potentially cause GALT tissue injury and inflammation and lead to breaches in gut barrier function (6). This feature can be attributed to published literature on poultry, in which waterborne pathogens have been reported to compromise gut immunity and microbial profile, hence lowering the general health and production of the birds (6, 7). Similar processes could exist in humans, whereby waterborne pathogens or toxins trigger exacerbations of gut inflammation and promote diseases such as IBD.

The gut-brain axis also provides the best example of the stiff systems through which water quality affects human health. Some of the substances generated by microbes in the gastrointestinal tract, with reference to water contaminants, impact not only the digestive system but also the nervous system (8). Consequently, of the toxicants in contaminated water, alterations in gut microbiota can invoke a wide range of effects in the host, including increased gut permeability, inflammation, impaired neuroendocrine signalling and so on (8, 9). For instance, research on pigs has shown how host microbiota modulates resistance to IBD and how microbial richness and resilience in the gut are critical for maintaining health (9).

The effects of water quality even reach the realm of treatment and procedures for gastrointestinal disorders. Transanal irrigation, an effective treatment for chronic constipation and bowel dysfunction, demonstrates the part played by water in promoting health in disease control (10). In addition, plans to modify the gut microbiota through diet change, including butyrate-producing bacteria, are emerging as approaches to reduce the effects of adverse rearing conditions like poor quality water (11, 12). Butyrate, an SCFA derived from gut bacteria, is critical for colonic epithelial cell health and reducing inflammation. It also proves that manipulation of the microbiota represents a feasible approach to addressing environment-associated stress (12, 13).

Growing information also indicates that specific ingestible components and food ingredients, especially water-soluble substances, may affect the composition and function of gut microbiota and the integrity of the intestinal barrier. Preservatives such as emulsifiers and other additives have been shown to have adverse effects on the gut and microbiome, therefore supporting the possible link

between environmental toxicants and the gut (14). Besides, the strains of Lactobacillus casei have a possibility of providing relief from the disease by balancing our microbiome, proving the effectiveness of microbiome therapies for IBD (15).

Objective: The objective of this study is to explore the relationship between water quality and gastrointestinal disease, focusing on the physiological impacts on gut function.

MATERIALS AND METHODS

Study Design: Cross-sectional.

Study setting: The research took place in both urban and rural sites in Pakistan with different types of water available such as municipal, bore hole and surface water.

Duration of the study: The study was carried out over six months, from January 2024 to June 2024.

Inclusion Criteria: Participants aged 18–65 years, residing in the selected study areas for at least one year, and reporting gastrointestinal symptoms or disorders were included.

Exclusion Criteria: Participants with pre-existing gastrointestinal conditions unrelated to water quality, those on long-term medication affecting gut health, or unwilling to consent were excluded.

METHODS

Water samples were taken from some urban and rural areas of Pakistan, including municipal water supplies, boreholes, and surface water sources. Aluminium foils accompanying these samples were also assessed for pH, total dissolved solids, turbidity, heavy metals, bacteria, and fungi. Information for clinical data was collected from quantitative questionnaires and the selected participants' patient records. Faecal samples were also taken from the subjects for assessment of the prevailing gut microbial profile and screening of pathogenic organisms. Biomarkers, including inflammatory markers like the C-reactive protein and the gut permeability tests evaluated overall gastrointestinal function and physiologic effects. These analyses were made to get an understanding of comparisons between the quality of water and factors related to stomach health. In this study, approval was sought and granted from a local institutional review board, and everyone consented to participate in the research. The findings shall seek to establish a relationship between 화 quality parameters and gut function and the epidemiology of diseases associated with the gastrointestinal tract.

RESULTS

The findings of this study' showed that water quality was strongly correlated with gastrointestinal illness. Two hundred water samples downloaded from both urban and rural regions were tested with respect to contamination and linked to 300 clinical records.

Water Quality Analysis

According to water quality analysis, 48% of analyzed water samples had a total microbial count above the permissible limit of E.coli being the most frequent pathogenic bacteria. Water analysis also showed that 35% contained high nitrates, and 28% had acceptable levels of lead and arsenic as heavy metals. Chemical pollution was concentrated more in urban areas, while microbial pollution affected rural regions the most.

Parameter	Urban (%)	Rural (%)	Total Exceeding Limits (%)
Microbial contamination	42	55	48
Nitrates	40	30	35
Heavy metals	32	24	28

Clinical Outcomes

Out of the 300 patients, 62 per cent of the respondents said they had experienced rigour through gut-related symptoms such as diarrhoea, stomach ache, and nausea. They also found that participants drinking water of higher microbial quality experienced significantly more symptoms ($p < 0.05$). In

addition, patients complained of certain symptoms where out of 19 symptomatic participants, 56% had altered gut microbial composition where there were low levels of Lactobacillus spp. and increased levels of opportunistic pathogens in their stools.

Gut Function and Physiological Impact

Inflammation biomarkers, including high CRP, were determined in 68 per cent of participants who were in contact with water that was of poor quality. Oral permeability tests were abnormal, suggesting that the intestinal barrier was compromised in 47% of patients. Research indicates that polluted water has a physiological effect on gut health.

Symptom	Percentage of Participants (%)
Diarrhea	45
Abdominal Pain	32
Nausea	28
Dysbiosis (Stool Test)	56

Seasonal Variations

Seasonal analysis revealed that cases of microbial pollution were higher during wet season, which cause presentation of many patients with gastrointestinal complaints. On the other hand, heavy metal concentrations were determined to be stable across the various seasons due to an industrial effluent source.

Season	Microbial Contamination (%)	Gastrointestinal Cases (%)
Dry Season	40	52
Wet Season	56	70

In general, the present investigation calls attention to the significance of water quality and its effects on enteric disease and on the requirements for more effective water security in both the urban milieu and the rural environment. The results also focus on the fluctuations of microbial threats and their impacts throughout the year.

DISCUSSION

As this research has pointed out, water quality plays a tremendous role in microbial proliferation and subsequent actions of disturbance in the human gut. The findings corroborate prior studies emphasizing the link between water quality, gastrointestinal diseases and pathophysiology in the human gastrointestinal tract. This research has established that water pollution, especially with pathogenic microorganisms, is responsible for gastrointestinal diseases, thus confirming that waterborne diseases are still important sources of morbidity and mortality in the developing world, including Pakistan.

The assessment of water quality showed that as much as 48% of water samples had higher microbial contamination levels in comparison with acceptable levels, and E.coli was the most common pathogen. This finding aligns with global reports that water pollution is one of the biggest causes of diarrhea (1). The presence of E. coli points to faecal contamination, which, again, is a pointer for waterborne diseases such as cholera, dysentery, and typhoid. Microbial contamination of water sources was higher in rural areas because such sources are unprotected and less monitored than in urban areas. This is in agreement with other studies that have shown that the incidence of waterborne diseases is higher in rural and peri-urban areas due to poor sanitation (4).

Finally, the rural residents reported that they found higher contents of chemical substances, including nitrates and heavy metals, in the water supplies of urban areas, which depended on city water systems. Water was classified as having high nitrate content, associated with agricultural pollution, in 35% of

samples. Nitrate pollution is also an important issue because it affects the flora of the intestines and helps in the development of diseases such as methemoglobinemia, especially for children (5). More alarmingly, 28% of these samples had heavy metals like lead and arsenic, which cause worry about exposure to toxic items. Indeed, prior research on heavy metals has established them as causes of gastrointestinal-related illnesses, which may have future implications for digestive health and the gut microbiome (6). The presence of these contaminants may result from industrial effluent discharge, leakage in sewerage or degrading water distribution systems.

These clinical findings of this current study are in agreement with previous findings on the effect of poor-quality water on the health of the gastrointestinal system. Gastrointestinal symptoms include diarrhoea, abdominal pain and nausea, with 62 per cent of participants experiencing these symptoms. This is in agreement with records on the effects of polluted water, most especially the drinking water anywhere else in the world. Diarrhoea was the most frequent symptom reported, showing signs in 45% of the participants. This is in concordance with other studies that revealed a positive relationship between water pollution through faecal material and diarrhea frequency (7). Besides, 50% of participants had gut dysbiosis, which means the presence of both pathogenic and beneficent bacteria in the gut. This suggests the need to recognize the role of the gut microbiota towards the gut and show how pollution affects the microbial community. Dysbiosis is recognized to be involved in different gastrointestinal diseases, such as IBD. It may cause systemic inflammation, as was shown in the current study, which showed an increased level of C-reactive protein (CRP) (8).

The effect on the physiological function of the gut was further evaluated for gut permeability tests, with 47% of participants from contaminated water experiencing altered gut permeability. Defined as the enhanced permeability of antibodies, or “leaky gut,” is aligned with chronic inflammation and is evident in IBD, IBS, and food allergies (9). This work emphasizes the chronic pathological effects of waterborne contamination. It supports the notion that waterborne agents are not just transient causes of acute illness but also influence long-term gastrointestinal pathology.

Notably, the research established seasonal trends in microbial pollution, with the E. coli count rising steeply during the wet season. In this regard, this period is characterized by running water from sewage or agricultural waste polluting the open water sources whenever it rains heavily. This concurs with the findings of earlier literature, whereby contracting waterborne diseases is most prevalent during this period as it raises the risk of interacting with faecal pathogens (10). The increased prevalence of gastrointestinal cases in the rainy season noted in this study, therefore, adds to existing evidence suggesting that environmental factors such as the amount of rainfall in any given season strongly influence the disease burden of waterborne diseases. Nevertheless, temporal variations in chemical contaminants, including heavy metals, are evident throughout both seasons and may provide evidence of chronic exposure risks due to industrial pollution and inefficient water handling systems.

Another weakness of this work is its cross-sectional descriptive study design; hence, it is impossible to establish causality between water quality and gastrointestinal diseases. Thus, though the research establishes a firm relationship, more specific longitudinal research is required in order to determine the impact of contaminated water on the digestive system. Furthermore, the study was conducted with specific attention to the differences between the urban and rural populations. However, other factors such as socioeconomic status, diet, or the impact of other pollutants on the environment were not considered, which could have been influential. Such variables need to be kept constant in future studies, and researchers should investigate their moderation effects on water quality and gut health.

The present study has specific significant implications for public health policy in Pakistan. This requirement is in a bid to address the high level of microbial contamination in the rural areas, coupled with the chemical product contamination in the urban areas. Also, there is a need for public health education to create awareness and encourage safe water use in a bid to decrease the morbidity burden of waterborne gastrointestinal illnesses. In addition, measures should be taken towards enhancing the standards for sanitation amenities and disposal of wastes significantly, especially where sources of water are contaminated by untreated sewage, as is common in developing countries.

Finally, this study offers great and helpful information concerning the effects of water quality on the physiological health of the gut and the overall gastrointestinal system. Therefore, the study calls for heightened efforts to enhance the safety of water supply in both urban and rural areas in Pakistan. Although microbial pollution is prevalent in rural areas, urban centres cannot also afford chemical impurities like nitrates or heavy metals affecting the lives of the people. The findings showed that an enhanced level of water quality control and an increase in awareness on the part of the public showed a positive correlation with the prevention of the incidence of diarrheal diseases that originate from contaminated water.

CONCLUSION

In conclusion, this study has endeavoured to emphasize the importance of water quality regarding gastrointestinal health, specifically addressing microbial and chemical contamination. According to the study's results, rural regions and cities of Pakistan are equally vulnerable to water quality issues. Some of the threats that are peculiar to the rural areas are microbial presence, while others that affect the urban areas include heavy metals and nitrates in the water supply. The link between polluted water and helminth, as well as enzymatic and other gastrointestinal diseases, including diarrhoea, gut dysbiosis, and impaired intestinal permeability, calls for immediate public health measures. Demands leading to effective water quality monitoring, better structures for water treatment, and more awareness to minimize the effects caused by water-borne gastrointestinal diseases are made in this study. Also, it is important to minimize contact with pathogens by covering foods during the rainy period, which is rich in contamination. Finally, the provision of safe water for consumption and proper sanitation is crucial for maintaining healthy intestines and ceasing lifelong gut disorders in societies with such compromised water qualities.

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