

Contaminated Irrigation Water: A Source of Human Pathogens on Growing Vegetables



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Abstract

People are being more comprehensive to the nutritional benefits of raw vegetables and have changed their eating habits. Undoubtedly, fresh vegetables are rich in nutrients, vitamins and minerals essential for health but with a downside of both epiphytic non-pathogenic and pathogenic bacteria like *Salmonella enterica* and *Bacillus cereus* causing illness. Soils irrigated with sewage water for raising crops and a soil nearby sewage disposal sites possesses the potential pathogenic load. The faecal index of such sewage water used for agriculture was above the maximum permissible limit of 100 MPN/ml (Recommended by Indian Environment Ministry). These food pathogens are predominately found on vegetables sourced from those regions and were characterized as highly virulent due to presence of disease causing genes in them. They have high multiple drug resistance index which pose a grave threat to public health. There is need to monitor the quality of irrigation water for public health safety. Further, the vending operations should be critically controlled to decrease the risk of contamination by improper storage and handling of the vegetables.

Keywords: Agriculture; Faecal; Sewage; Fresh vegetables; Pathogen

Abbreviations: Most Probable Number (MPN)

Introduction

The reported outbreaks of gastrointestinal disease in recent years are directly linked to contamination of fresh produce like tomatoes, spinach, lettuce and seed sprouts with Enterobacteriaceae members viz. *Salmonella* spp., *Escherichia coli* O157:H7 and *Shigella* spp. Other bacteria associated with the food poisoning outbreaks are *Campylobacter* spp. and *Listeria monocytogenes* [1,2]. Bacteria use plants as a vector/ vehicle for their dissemination to new areas. They tend to become dormant due to low population threshold but nutrient availability from vegetables and temperature abuse during storage soar up their threshold to the state of pathogenicity in human or animals. Bacteria manage to survive adverse environmental conditions as localize in protected niches via root internalization, stomata, or during physical or biological damage to plant organs [3,4]. *Salmonella* and *Escherichia coli* O157:H7 have high survival ability on fresh herbs for at least 24 days at refrigeration temperature [5]. Horizontal transfer of resistance contributes to multiple antibiotic resistances in epiphytic as well as pathogenic microorganisms in fresh produce [6]. The survival of disease causative agent under different environmental conditions represents one of the factors which determine the spread of diseases between the consumers of contaminated water or food

[7]. Untreated sewage water is being used for crop irrigation in many developing countries. Sewage irrigated Ready-to-eat (RTE) samples drawn from Hidalgo, Mexico, harboured faecal coliforms, *Escherichia coli* and diarrheagenic *Escherichia coli* [8]. In Punjab - Buddha Nallah and its sewage polluted water is distributed throughout the Ludhiana District via irrigation canals and used for agriculture purpose. The vegetables grown in such regions are at high risk of carrying the disease causing microorganisms. The surface water analysis of one of the water channels of Budha Nallah reveals high values of total dissolved solids up to 1642 mg/L, chlorides up to 400 mg/L, Chemical Oxygen Demand values up to 448mg/L, Biochemical Oxygen Demand 52-195 mg/L, Most Potable Number varying from 240+ upto 2400+ per 100ml, heavy metal like Cr in the Budha Nallah has value 0.031 mg/L, Fe 0.913 mg/L, Mn 0.043 mg/L and Ni 0.222 mg/L [9]. The groundwater quality, however in recent time has got deteriorated due to the percolation of polluted water along Buddha nallah. High MPN index (upto 2400) of water samples collected from adjoining regions along Buddha nallah was reported [7]. The limit of faecal coliform at 10MPN/ml is desirable as recommended by Indian environment ministry with maximum permissible limit at 100 MPN/ml for discharge of treated sewage into a water body or reuse for agriculture.

Decaying organic matter is one of the most frequent reservoirs of human pathogens that cause the contamination of growing vegetables through soil leading to the transient colonization of the human intestine. According to Bureau of Indian standards (BIS), fresh produce must be microbiologically safe for consumption, regardless of any processing or transportation. According to the report of Center for Disease Control and Prevention in 2016 [10], an outbreak related to contaminant Salmonella in cucumber was expected in America. Many researchers have found Salmonella in lettuce, spinach, tomato, radish [1,11]. Due to changing eating habits and increase in consumption of Continental and Chinese cuisines using indigenous vegetables, risk associated with virulent food borne pathogens is also increasing. The present study was conducted involving epidemiological surveillance of seven fresh vegetables generally consumed as raw due to their higher nutraceutical properties. Evaluation of the microbiological quality of seven fresh vegetables being grown along the Buddha Nallah, Salmonella enterica count in range of 4.32 to 5.09 log cfu g⁻¹ and Bacillus cereus count from 2.69 to 4.35 log cfu g⁻¹ was recorded in samples of carrot, radish, cucumber, tomato, cabbage, spinach and long melon [12,13]. Many other human pathogens were also found including E. coli, A. hydrophila, S. flexneri, L. monocytogenes, Y. enterocolitica, C. jejuni, V. cholera, K. pneumonia and S. aureus were also detected on fresh vegetables.

The source linked with the risk of contamination can be the irrigated water, improper handling, storage and transportation. The presence of bacterial pathogens in irrigated water and soil is also a cause of drug resistance among microbial community. So, constant efforts were made to evaluate the persistence of pathogens on the basis of virulence factors and antibiogram profiling involving the clustering analysis for diversity study. Certain epidemiological studies have illustrated the Multi Drug Resistant (MDR) Salmonella enterica and Bacillus cereus predominately present in fresh produce [12-15] (Annexure I, II). Resistance to antibiotics like ampicillin, Cloxacillin, Tetracycline, chloramphenicol and trimethoprim-sulfamethoxazole [12,13,15] against salmonella strains has been cited which can reflect the seriousness of the drug resistance issues. The mobility of these pathogens from field to fork and their virulence expression in mammalian cells can detrimentally effect the public health and safety.

The detection of pathogens in food is always cumbersome and food related illness often go unrecognised in India. Traditional culturing methods take 4-7 days for confirmation and are not much reliable. Many molecular tools have been used now-a-days to circumvent such issues and detect the pathogens present in their minimum concentration. A PCR based detection protocol has been developed and effective remedial measures have been suggested to counter the risk of health hazards associated with fresh vegetables [16]. A rapid yet inexpensive detection technique based on the Multiplex PCR was devised in which hblD gene (430bp fragment) of B. cereus; ystA gene (79bp

fragment) of Y. enterocolitica; invA gene (280bp fragment) of S. enterica and iap gene in L. monocytogenes (225bp fragment) were targeted. This approach can be used as an alternative method for the routine microbiological analysis of food samples. The high sensitivity, specificity and cost effectiveness can make this an ideal test for screening of possible contaminated food samples.

The quality of water used for irrigation of fields along Buddha nallah was assessed by drawing out the samples from the hand pumps of village fields. The results with high MPN index of >10ml⁻¹ were found in 75.6-98.5% of samples for total coliforms and 59.6-91.2% for faecal coliforms [12]. This substantiates the fact that ground water is contaminated with faecal coliforms due to the percolation of sewage water of Buddha nallah. Very little attention was given to the traditional processing methods. The vending operations in the city attempting to meet the food demand of the inhabitants pose their health in risk as the street food contain human pathogens in suffice to cause a serious disease [17]. India witness many food borne illness cases due to consumption of food from street vendors [17,18]. Such trading practices without any hygiene interventions may help these epiphytic pathogens to flourish and reach a virulence threshold.

Conclusion

The study conducted so far for the quality of fresh produce in the village fields along Buddha nallah apparently indicates the risk of illness associated with its consumption. This further led the researchers to evident the ground water in village fields near Buddha nallah as immediate source of contamination which the plants are inheriting. The high level of BOD, COD and nutrient availability to human pathogens in sewage water can increase the threshold of their virulence. The farming practice in those regions cannot be avoided as many families rely for income on this trade only. The efforts should be made in treating the water of Buddha nallah so as to reduce the organic matter and the faecal coliform content to permissible level for agriculture use.

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