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Root Cause Analysis of Contamination of Water in a Tertiary Care Hospital

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Abstract: ***Introduction: Water is a main source of various microorganisms especially in developing countries. The goal of bacteriological quality monitoring is to assure the safety of drinking water for consumers and to monitor the performance of treatment processes. One of the cardinal principles of hospital care is that it should cause no harm to the patient. However, if the water supply in the hospital setting is unsatisfactory patients may acquire various infections in hospital. Objective: The present study was carried out to identify the root cause of presence of repeated coliforms in water samples received from various areas in the hospital. Methods: Water samples were collected from various sites as part of routine surveillance and were checked for presence of coliforms. Further stepwise approach was taken for the root cause analysis of contamination of overhead tanks, water supply pipelines and underground water source. Result: Two, out of 3 underground sources, were supplying water heavily contaminated with coliforms like Escherichia coli due to leakage in nearby septic tanks. Both the sources were closed permanently and septic tanks were repaired. Supply was carried out only from third source. Repeat testing of water samples after few weeks later was free from coliforms. Conclusion: The contamination of underground water was identified as defect in the septic tank located nearby. This was possible only because of regular analysis of water by Microbiology department and systematic approach to find out the root cause by Community medicine departments. Bacteriological assessment of all water sources for drinking should be planned and conducted on regular basis to prevent water borne infections especially in hospital setting.***

Keywords: water analysis, multiple tube method, coliforms, *Escherichia coli*

1. Introduction

The goal of bacteriological quality monitoring is to assure the safety of drinking water for consumers and to monitor the performance of treatment processes. Monitoring focuses on indicator organisms because bacteriological pathogens are rarely isolated from drinking water due to their low numbers under normal circumstances. The principal bacteriological indicators are coliforms (like *Escherichia coli, Klebsiella species*), *Enterococci and Clostridium perfringens.*[1]

Coliform bacteria are a broad group of microorganisms that can be found in soil, decaying vegetation, water and faeces. *E. coli* are considered to be exclusively faecal in origin, and some strains are pathogenic. Their presence in drinking water supply does not always indicate threat to health, but could point to a problem with treatment operations or a breach in the distribution system. *Enterococci* do not multiply in the environment and can occur normally in faeces, but their numbers are much smaller than those of *E. coli* bacteria. Though *Clostridium perfringens* are able to persist for longer than coliforms and Enterococci through the formation of spores they are present in faeces in much smaller numbers and there is disagreement about their correlation with pathogens.[2]

Detection of these microorganisms in drinking water is indicative of environmental or faecal contamination of treated water.[3]

One of the cardinal principles of hospital care is that it should cause no harm to the patient. However, some patients may acquire infections in hospital due to various reasons.[4]Patients who are immunocompromised (e.g. solid organ transplantation, stem cell transplantation, malignancies) are at a high risk for severe gastrointestinal infections caused by viruses, bacteria and parasites, leading to significant morbidity and mortality and severity of diseases as compared to healthy individuals.[5]Surveillance of the drinking water supply is a routine practice in our Hospital. On analysis, we observed a repeated growth of coliforms in almost all the water samples collected, much more than observed usually.

Therefore, a massive task was carried out by Department of Microbiology in collaboration with Department of Community Medicine and Hospital Management to identify the root cause of presence of repeated coliforms in water samples received from various areas in the hospital so that appropriate measures can be carried out to prevent outbreaks in future.

2. Methods

This was descriptive, cross sectional, epidemiological study.

Study setting
850 bedded tertiary care hospital with 1400-1600 outpatient care per day.
Study period
Period of 6 months from March 2019 to August 2019

Procedure
Hospital infection Control Laboratory (HIC Lab), Department of Microbiology regularly collects water samples from various areas of the hospital as per the routine surveillance schedule. Sterile water bottles were given for collection of water.

Sample collection & transport:
Drinking water sample was collected from taps, water cooler and filters as per the standard protocol[6] Briefly, the mouth of the tap/dispenser was cleaned with 70% ethanol to sterilize the tip from which sample was collected and the water was allowed to run for two minutes before collection the mid-stream sample in a sterile 250 ml screw capped glass bottle. The sample bottles were labeled with the site of collection, time and date of collection of water, [7, 8] and transported within 50-60 minutes of collection to HIC Lab for testing.[9, 10]

Bacteriological analysis of water:

Procedure
The most preferred and cost effective method for detection of coliforms is the Most Probable Number (MPN).[6] A set of double and single strength McConkey purple broth with inverted Durham tubes were inoculated with measured amounts of water to be tested. The coli forms ferment the lactose present in the broth producing acid and gas. The MPN of coliforms present in 100 ml of water is estimated by the number of positive tubes using Mc Cardy table.[7] The media, reagents and chemicals used was purchased from Hi Media Pvt. Ltd. Mumbai. All media prepared and used had passed the sterility check before inoculation of water samples.

Briefly, 50 ml of water sample was inoculated in 50 ml of double strength Mac Conkey broth purple in sterile screw capped glass bottle. [Fig.1a] Ten ml of water sample was inoculated in each of the five tubes containing 10 ml double strength Mac Conkey broth purple (first row) and 1ml of water sample was inoculated in each of the 5 tubes containing 5 ml single strength Mac Conkey broth purple (second row). All test tubes / bottles contained Durhams tube for observation of gas production. [6]

The inoculated bottles /test tubes were incubated at 37^0C for 24hrs and were observed for presence of turbidity with acid and gas production. [Fig.1a & Fig.1b].

The bottles/ tubes without any turbidity and no acid and gas production were further incubated for 24 hours and were reported as satisfactory and fit for drinking after a turnaround time of 48 hours. However, the tubes with positive growth (turbidity/acid & gas production) in the bottle / tubes (single and double strength) were noted and MPN was calculated with the help of Mac Cradys probability table and the MPN of coli form in 100 ml water was estimated.[7, 8]

Further, the positive samples with unsatisfactory MPNs were subjected for Eijkmans test for the presence or absence of thermoterant *E.coli* in water which is an indication of recent fecal contamination of water by biochemical reactions; Indole test, citrate and growth at 44^0C. [6]

3. Results

The water committee evaluates the result of water analysis from hospital and college fortnightly on routine practice. However, unsatisfactory MPN/100mL and presence of *E. coli* in any report marks urgent meeting at any point of time. Presence of *E.coli* was found in water samples collected from various sites like wards and OPD.

For source tracing, the overhead tanks were inspected there was no breach in lids or body. Routine cleaning was carried out and water from the tank was found to be microbiologically satisfactory. Few minor contamination opportunities were found for which corrective action and preventive action (CAPA) was taken. Retested samples again came out positive for coliforms.

Thereafter, an emergency meeting of water committee was called along with members from the maintenance and engineering department of University and a thorough discussion about the drinking water distribution system was carried out. The map of all the water supply pipelines was re-explored so as to trace the source and contamination in pipelines was checked for any breakage or negative suction by the specialist of maintenance departments far as possible. [Fig 2]

However, in spite of all this effort no major fault was identified in the infrastructure. After minor repair the repeat water sample checked was again found to be positive for *E.coli.*

On further, probing it was found that our hospital receives water from 3 underground sources [Fig.3].Source 1 (S1) receives water from a depth of 150 feet located separately and source 2 (S2) and source 3 (S3) located next to each other on the other side of the building received water from depth of 130 feet each. Water from S2 and S3 was found to be positive for thermo tolerant *E. coli* while S1 was free from all the pathogens. On getting the frequent unsatisfactory report the S2 and S3 were closed temporarily for almost 2 weeks and the hospital received water only from S1. After few weeks of this repeat water samples checked from all the dispensing sites came out to be free from coliforms.

Two, out of 3 underground sources, were supplying water heavily contaminated with coliforms like *Escherichia coli* due to leakage in nearby septic tanks.

Both S2 and S3 sites were further re-explored for the presence of any breach in the nearby septic tank or drain as it had grown thermo tolerant *E.coli* which is an indicator of fecal contamination. Root cause for drinking water contamination by coliforms was identified as due to leakage in nearby septic tanks nearby site S2 and S3. Thereafter both the sources were closed permanently these 2 sources were permanently closed these and septic tank was repaired. Supply was carried out for the time being only from third source and to fulfill the water demand of the hospital an alternate boring site were proposed and work was started. Repeat testing of water samples after few weeks later was free from coliforms.

Figure 1(a): Mac Conkey purple broth showing turbidity with acid and gas production indicating bacterial growth in water.
Figure 1 (b): Pure growth of *E. coli* on Mac Conkey Agar plate after subculture from turbid media in bottles

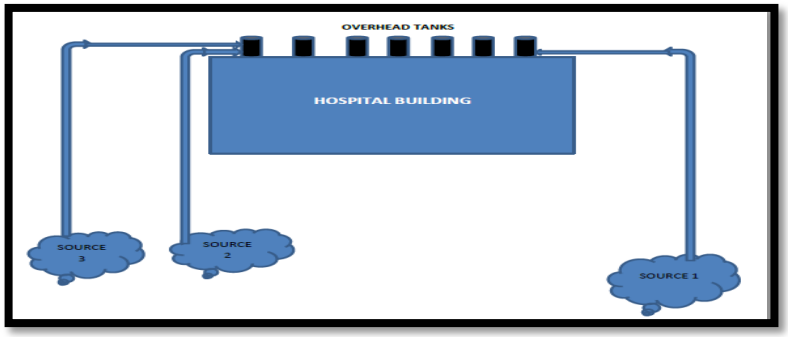

Figure 3: Distribution of water in the Hospital building from 3 underground sources represented by Source 1 (S1), Source 2(S2) and Source 3 (S3).

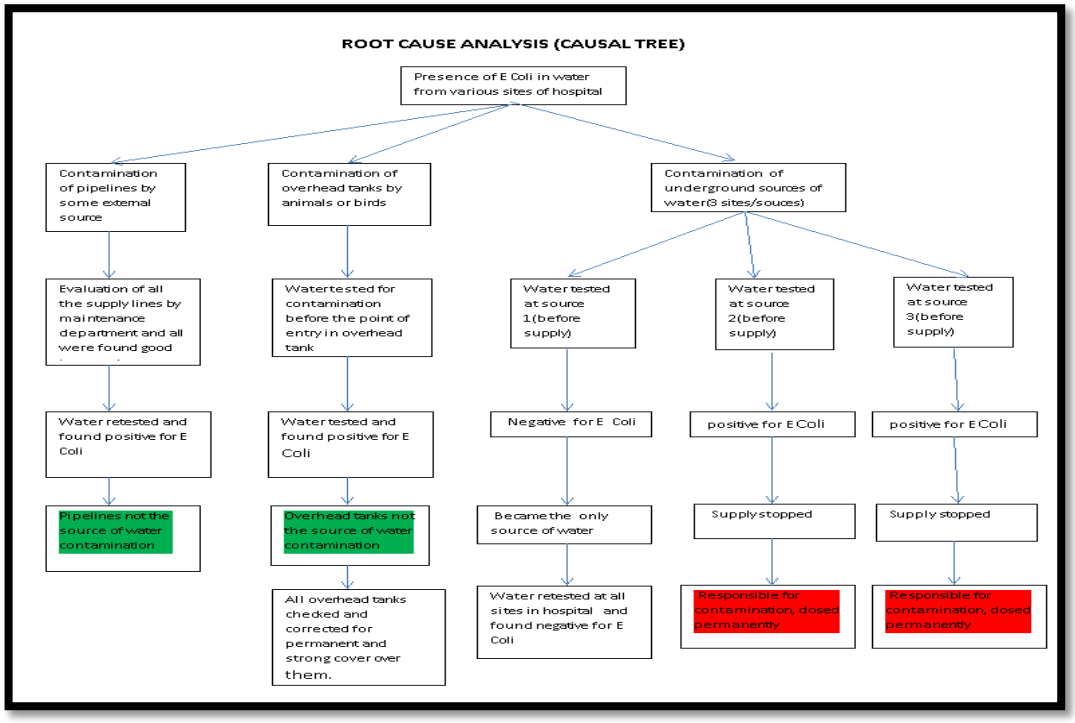

Figure 2: Flow chart showing root cause analysis & source tracing of water sample from the Hospital

4. Discussion

As per the standard guidelines of water testing, presence of thermotolerant *E.coli* in water is an indication of recent fecal contamination of water.[6]The systematic investigation from one side of the water supply was carried out. First and foremost step was to check the overhead tanks for any possible source of contamination of water by *E. coli* excreted in faeces of animals especially monkeys and birds which is possible due to broken lid/ no lid in the tanks. However on inspection by the team no major fault was observed, all the lids were closed and there were only minor problems like lock of few lids were broken which were successfully corrected.

The second step was to check the water supply pipelines for breakage / leakage in supply which may cause negative suction and may be responsible for contamination of water. Apparently we found no broken pipelines as far as we could trace.

Ideally the ground water supplied from depth is fit to consume without any treatment. However, in our case the ground water was found to be contaminated not only with unsatisfactory MPN but also positive for Eijkeman test. Our finding is consistent with a study carried out by Sharma *et al*[12] in Lucknow, who also found coliforms in ground water. Another study by Gupta *et al*[13] from Uttar Pradesh Gorakhpur also found coliforms in ground water. Similarly, Thirumalesh in Bengalore found many bore wells with coliforms [14] and Sreekala *et al*[15,] Susiladevi*et al*[16] found termotolerant coliforms and *E.coli* in the of Central Kerala and Cuddalore town, Tamil Nadu.

Central Pollution Control Board (CPCB) in 2007 had carried out a multicity study across India for ground water evaluation.[17]In the report given by them Meerut city ground water did not have any coliforms. However, nearby city like Agra had coliforms in underground water. The report by CPCB revealed ground water contamination by coli forms in many cities of India.

The common sources for coliform contamination in ground water maybe by leakage from sewage, landfills, septic tanks & livestock'[17].A large part of un-collected, un-treated wastewater finds its way to either nearby surface water body or accumulated in the city itself forming cesspools. The wastewater accumulated in these cesspools gets percolated in the ground and pollute the groundwater. Also in many cities/towns conventional septic tanks and other low cost sanitation facilities exists. Due to non-existence of proper maintenance these septic tank become major source of groundwater pollution

5. Conclusion

Underground water fetched from source which is close to any septic tank should be regularly screened for coliforms contamination. Septic tanks should be regularly inspected and repaired as these can contaminate underground water sources

The contamination of underground water was identified as defect in the septic tank located nearby. This was possible only because of regular analysis of water by Microbiology department and systematic approach to find out the root cause by Community medicine departments. Water may get contaminated at various levels therefore an efficient and well-maintained distribution system will ensure safe water supply at the point of collection and consumption. Bacteriological assessment of all water sources for drinking should be planned and conducted on regular basis to prevent water borne infections especially in hospital setting.

For future perspectives, water committees will continue monitoring at regular intervals, of both water sources and supplies for prevention of water borne diseases in our healthcare settings and community.

6. Conflict of Interest

There is no conflict of interest in this study.

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