Challenging the WHO Prescribed Sanitary Inspections for Contamination of Tubewells with Handpump

Mukul Kulshrestha, Nagendra Prasad Singh

Abstract*: WHO prescribed sanitary inspections constitute useful monitoring tools, besides being effective and economic in identifying drinking sources of water at risk in terms of contamination. In the present case, the contamination risks in potable waters from Tubewells fitted with handpump were evaluated across 9 districts in India. Field inspections were conducted in WHO prescribed format on Three Hundred Twenty Four sources of potable water used by the community for withdrawing drinking water to evaluate occurrence of contamination risk. The theoretical risk thus assessed was then compared with actual test results of biological testing in the laboratory for assessment of Coliform bacteria using a standard MPN test.

The results of the study indicate that WHO format based sanitary survey results are more stringent than reality, and hence overestimate the risk. The results also indicate that the risk categories are mostly distributed with a majority of risk focused in the middle in the High and Medium risk categories.

Keywords: WHO prescribed Sanitary inspections, risk of contamination, tubewells with handpumps, Coliform bacteria, MPN Test

I. INTRODUCTION

Roughly, water occupies more than two-thirds of the earth's surface, but only around 2.5% of water is freshwater. 70% of this freshwater is in frozen state spread across ice-caps, and hence unavailable for easy use. Also, out of the remaining part, a significant portion is locked - either as the soil moisture on the surface, or deep as part of the under-ground aquifers, and hence is effectively not accessible. Overall, not even 1% of global fresh-water resources actually are available for human consumption and usage [1], [2].

In the last century global fresh-water usage has increased 6-fold – which is greater than twice the growth rate of population increase [3]. As a result, nearly 460 million humans residing in 31 countries , and comprising nearly 8% of global population, fall into highly water-stressed areas, while another 25 percent of Earth's human population reside across countries with severe water-stress [4],[5]. It may be noted that water stressed areas are where the annual water-supplies are less than 1700 m^3 per capita. Where the annual water-supplies are less than 1000 m^3 per person, the region is termed water-scarce [5],[6].

The above scenario will in all likelihood worsen in the near future. By the year 2025, 67% of the global population across 48 nations shall reside in countries that witness moderate or severe water-shortages [7],[8]. By the year 2050, it is feared that 54 countries could face water- stress or scarcity affecting as many as 4 billion humans. All relevant data indicates the precious nature of the natural resource-the water, which like all other resources needs to be exploited with caution and used efficiently within the limits set up by the providence in contrast to its wasteful usage currently.

Despite the critical significance of water to human-life, the water-sector has witnessed continual political apathy, poor-regulation and mis-governance, and significant underinvestment etc., manifesting in high sector inefficiencies. These inefficiencies are prevalent across all water usages: in agriculture, food processing, water supplies, and in industrial usage. As a consequence, worldwide hundreds of millions of humans would remain trapped in ill-health and resultant poverty and misery, and would remain vulnerable to water-related disasters, and to environmental degradation that may bring about even political instability and seriously disruptive conflicts [9].

Water being one of the most scarcely available natural resources, its effective and efficient usage is a major concern globally. Water crisis may occur across sectors- domestic, industrial, agricultural or hydroelectric generation. Irresponsible and unplanned water usage may result in widespread deterioration of environmental and social state of affairs, that can lead to alarming situations, and these issues are already being highlighted in media on a regular basis. Water being the limiting resource across the world, there has been global emphasis on measuring and increasing efficiencies of water supply schemes. For instance, Marques et.al [10] studied the water utilities in Japan for several factors that influence efficiencies, while Mukul Kulshrestha and Amit Vishwakarma [11]; Amit Vishwakarma et al [12]; and, Sai Amulya Nyathikala and Mukul Kulshrestha [13] analyzed efficiencies for Indian water supplies. Similarly, Cruz et al [14] analyzed performances of Portuguese and Italian water-utilities by employing composite (global) indicators on sampled 88 water-utilities.

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While there is so much of stress on ensuring adequate water quantities, the water quality issues worldwide remain a major cause of concern. Insufficient water and sanitation reflect in mammoth burden of death or disease in poorer countries, besides forcing millions to compromise upon health, thereby denying them the right to live dignified human lives. The Population Report [15] details the studies that link three-fourth of all Bangladesh diseases to inappropriate and insufficient Water & Sanitation, while a quarter of all patients in hospitals across Pakistan get hospitalized for diseases that are linked to water [16]. Inadequate water and sanitation lead to morbidity and mortality, besides bringing about immense health-costs, decreased work-productivities, lesser school-enrollments, higher child-mortalities, and increased family sizes due to risk aversion brought about by lesser survival rates of children and infants, and hence to increased poverties.

With Indian government redefining its priority to "Water to All by 2024" [17], new research possibilities have emerged on critical evaluation of decentralized water sources that supply water to a vast majority of rural India, where piped water distribution has either not reached, or is unreliable and even non-functional. This implies renewed interest on critical evaluation of water monitoring, surveillance, and quality assessment of decentralized water supply sources in rural areas, including the handpumps and tubewells, and tubewells installed with a handpump.

In order to avoid of testing water samples from millions of such sources mostly in villages, a sanitary inspection format has been prescribed by WHO [18] in which inspection data is collected on 10 parameters, to evaluate the extent of risk. These 10 parameters are listed in Table 1, from where risk scores from any supply source may also be determined.

II. WORK OBJECTIVES

The objective of the work was to assess if the Risk scores as per the WHO inspection formats correlate, and if so, to what extent, with the actual prevalence of bacteriological contamination derived from MPN test carried out in laboratory. A positive high correlation would imply that WHO prescribed formats are good enough to suit Indian conditions; while any negative correlation would imply a rejection of WHO criterions, and hence establish the need to evolve our own indicators of risk in the Indian context.

Table 1. WHO prescribed format for assessing Sanitary Risk

S. No.	Specific diagnostic information for assessment	Risk Score (Yes=1 No=0)
A	Is there a latrine within 10m of the hand-pump ?	1 or 0
B	Is the nearest latrine on higher ground than the hand-pump?	1 or 0
C	Is there any other source of pollution (e.g. animal excreta, rubbish, surface water) within 10m of the hand-pump?	1 or 0
D	Is the drainage poor, causing stagnant water within 2 m of the hand-pump?	1 or 0
E	Is the hand pump drainage channel faulty ? Is it broken, permitting ponding? Does it need cleaning?	1 or 0
F	Is the fencing around the hand-pump inadequate, allowing animals in?	1 or 0
G	Is the concrete floor less than 1m wide all around the hand-pump?	1 or 0
H	Is there any ponding on the concrete floor around the hand-pump?	1 or 0
I	Are there any cracks in the concrete floor around the handpump which could permit water to enter the well?	1 or 0
J	Is the handpump loose at the point of attachment to the base so that water could enter the casing?	1 or 0
	Total Score ΣA to J Max 10,Min 0	*Risk Score Value*

Source- [18]

III. WORK METHODOLOGY & DATA COLLECTION

As per the format prescribed by the WHO, total risk scores were evaluated for a sample of 324 community Tubewells with handpump. The work was undertaken in 9 districts of the State of Uttar Pradesh in India- Sidharth Nagar, Sant Kabir Nagar, Allahabad, Gorakhpur, Moradabad, Maharajganj, Kusinagar, Basti, and Deoria during the period 2014-2017.

Inspections formats were filled up for all 324 sampled Tubewells with handpump. At each of these points grab samples were also picked up for testing the microbial water quality in terms of MPN test for coliforms carried out as per the Standard Methods [19]. The Methodology is explained in brief in Fig 1.

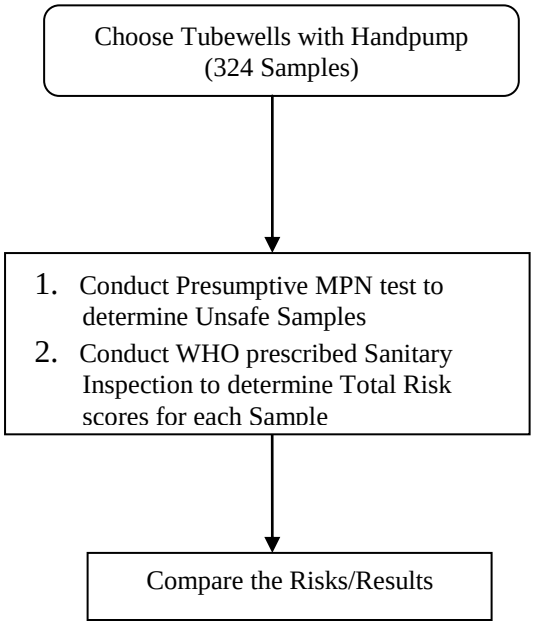

Figure 1. Work Methodology

The distribution of overall risk was categorized as Very high risk (total risk score from Table 1, in the range 9-10), High risk (total risk score in the range 6-8), Intermediate (Medium)

risk (in the total risk score range 3-5) , and Low risk (risk score in the range 0-2). These risk scores were then compared with lab analysis results for MPN test.

IV. RESULTS AND DISCUSSIONS

A. Results of Lab Analysis

The survey results from the laboratory analysis for MPN test conducted as per the Standard Methods (2012), indicated that out of the 324 samples, 122 cases tested positive for the presence of coliforms. These 122 samples were suspect cases, where the risk of contamination from the sanitary inspection data, existed to varying degrees. These 122 suspect cases identified with positive MPN test were subsequently reviewed for their sanitary inspections survey results conducted as per the WHO format. These sanitary survey risk categories for 122 field positive MPN results are presented in Figure 2 which shows the Distribution of risk categories from the WHO format based sanitary survey results for the 122 "Unsafe" suspect cases.

It is evident from Figure 2 that contamination risks from WHO sanitary surveys are mostly distributed towards high and medium category of risks, with these two categories alone accounting for 70% of unsafe samples. The very high risk category was rare with only 6% of the sample tubewells with handpump which tested unsafe having this category, and from which water should not be used for drinking purpose unless alternative sources are not available, or appropriate water treatment is carried out.

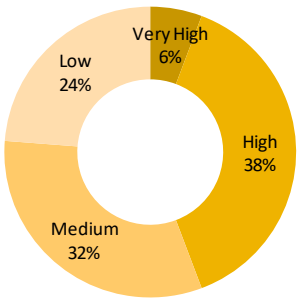

Figure 2. The Distribution of Risk for Contaminated Unsafe Samples

B. Results of Safe Tubewells with Handpump

In the laboratory analysis conducted to test the presumptive MPN count for coliforms, no coliforms were detected in 202 samples. These cases, 202 in numbers, reported absence of Coliforms, and hence were certainly "Safe" in terms of risk of pathogenic contamination.

These Safe samples were then correlated to their sanitary inspection data already collected in the WHO format. The distribution of risk levels in the sanitary survey result of these 202 samples is presented in Figure 3.

Figure 3 illustrates the fact that most of the results of sanitary-inspections for safe Tubewells with Handpump fall in the High risk catgory (57%), while 28% of the results fell in the Intermediate or Medium category. Thus, a whopping 85% of inspection results for the Safe Tubewells with handpump actually expected Medium to high risk, and yet were acuallty found risk free in reality based upon the MPN test results of the samples.

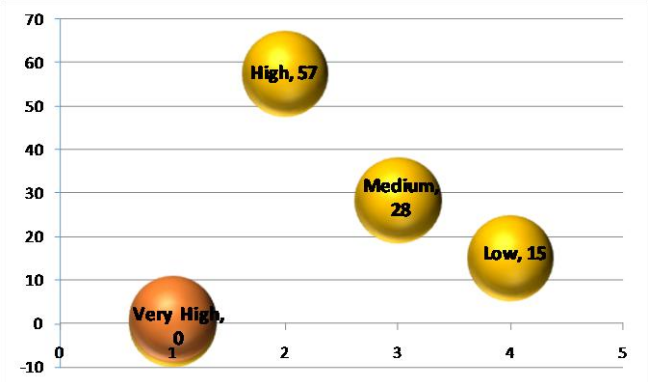

Figure 3. Sanitary Survey Risk % for various Risk Categories for "Safe" (Zero MPN) Samples and distribution of Risk

V. CONCLUSIONS

The results of the analysis point out to the fact that WHO sanitary inspection results are more conservative and rigorous than the reality. While only 122 samples were MPN positive, the WHO sanitary inspection yielded risk factors for all the 324 samples survey results in the field. It is a welcome outcome from the perspective of consumers, who would not mind over-estimation of risk, and also from the point of field managers and engineers, making them lose complacency since sanitary survey results on which they invariably are dependent in the field would make them overcautious even in cases which are apparantly Safe. However, this is a bad outcome from a policy perspective. If the planning and policy are based on overzeoulous risk perceptions, which the WHO sanitary inspections would rather make appear, then there would invariably be budgetary over-allocations and over-planning for risk in an otherwise financially constrained sector. Also, resources including the human resources that are always in scarcity will remain overstretched due to heightened sanitary risk perceptions from WHO sanitary surveys.

For both the Safe and the Unsafe categories based on test results in the lab, it was found that maximum risk as per WHO sanitary inspection results occur in medium and high risk categories. For the Unsafe category this medium and high risk occuranc was 70%, while for the Safe category, this occuarnce was as much as 85%. Thus, risk is more likely to be foccused towards the middle of the distribution.

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