Effect of drinking water quality on non-communicable diseases with special reference to fluorosis in Haveri district, India

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KEYWORDS

NCD, Fluorine, Haveri, Dental fluorosis, quality, water, community

ABSTRACT

The concentration of fluorine and mineralisation exceeds in the potable water leads to the arise of NCD (Non-communicable Disease) in India. It also generates adverse impacts to the children. There are numerous disease caused to human in association with the poor quality of water. In addition to, the extra burden is the prevalence of NCD due to poor sanitation. Hence, the present research aims to examine the characteristics of drinking water in Haveri. Also, it examines the existence of fluorosis among the populace of Haveri. The populace are investigated regarding the quality of drinking water. The present study implements quantitative techniques utilizing the software package SPSS version 23. An organised questionnaire survey practice is applied to gather the data from the populace of Haveri. Purposive sampling strategy has been implemented for data analysis. The goal behind the system is to gather data associating to the quality parameters of the drinking water and its impact on the prevalence of dental fluorosis. Descriptive statistics and chi-square tests are accomplished in the study. The outcomes of the study reveals the phyisco-chemical characteristics of drinking water in the pre as well as post monsoon period. Furthermore, the study also evaluate the dental and skeletal fluorosis existence in the regions of Haveri. The study also focus on investigating the association amongst the quality of drinking water and NCD in the district of Haveri. The study recommends the Government to provide quality water to the community for the minimisation of NCDs prevalence among the region of Haveri.

1. Introduction

1.1 Theoretical background

The eminence of drinking water is a persuasive element of wellbeing in the atmosphere [1]. It is assessed through the three chief classes likely physical, chemical as well as microbiological properties [2]. Moreover, the existence of organic compounds, heavy metals, turbidity and total suspended solids (TSS) are detected by means of physical as well as chemical properties [3]. Subsequently, the microbiological constraints encompasses *E. coli*, coliform bacteria and other certain pathogenic species. For example, cholera which is caused by the bacteria *Vibrio cholerae*, protozoan parasites and viruses [4]. Frequently, chemical constraints tends to cause a health risk by means of the slow as well as constant accretion of heavy metals [5]. Even though, certain components likely nitrates/nitrites as well as arsenic resulted in causing the instantaneous impact. Alternatively, physical constraints affect the taste and aesthetics of the drinking water. Also, it might generate complication in the eradication process of microbial pathogens [6]. It is immense importance to consider the vulnerable populace those who are prone to expose. It also encompasses the children, older populace as well as immune-suppressed community [7].

Water is significant for the vital functioning of the body and also provide hydration. It is essential for the survival of the living populace. Water should be clean as well as safe for the health protection and their survival [8]. The consumption water might be contaminated via biotoxins, microbes and chemicals leading to the ill health and also causes pre-mature death [9]. Meanwhile, the epidemiologic studies proved that there are noteworthy association

amongst the hard water and soft water and high prevalence of cardio-vascular symptoms [10]. Also, there is evidence of cancer and abnormalities in reproductive system [11, 12] [13].

There is an evidential report of the utilisation of water from the unsafe resources by the twenty percent of total world's populace. Alternatively, thirty-two percent from the protected sources and forty-eight percent from the purified water supplies through pipes [14]. Almost, 900 million populace are restricted to access the purified drinking water. Subsequently, seventy percent of the populace consume water from their homes and remaining acquire water from the schools and workplaces [15]. Additionally, they acquired a considerable quantity of water through the beverages and food. The beverage encompasses eighty percent of water consumption and food is considered to be the chief source of micro as well as macro nutrients for the living beings.

The developing nations faces the issues of scarcity and it begun to utilise water from the rainwater, recycled water as well as desalinated water. It also acquires water from the tube wells in the past 5 decades. The hardness of water has been found to be high in the tube wells [16] which are estimated through $CaCO_3$ equivalents. It is chiefly due to the dissolution properties of magnesium and calcium. Additionally, it also consists of the naturally existed components likely fluoride [17].

NCDs (Non-communicable Diseases) are termed as it is caused in long extent. Subsequently, these are portrayed to be non-infectious circumstances which are not communicated to other populace [18]. Although, NCDs develops slowly or else causes symptoms that necessitates pro-long care alternatively, others develops promptly [19]. Even though, it affects adult men as well as women but children are susceptible. People seems to have good health status but suffer from the adverse conditions [20].

The serious concerns regarding the NCDs is, they seems to affect productive years of populace. Also, it causes "premature deaths". It is a death happening prior to the average life anticipation [21]. Even though NCDs causes impacts to a person of any age, the older populace are vulnerable. The five common NCDs are cancers of oral, cervical, breast, diabetes and hypertension.

There are supplementary NCDs likely asthma, epilepsy and respiratory syndromes [22]. Hence, the present research aims to detect the fluorosis prevalence and also examines the association of NCD and water quality in the region of Haveri.

1.2 Significance of the study

NCD are prevalent in both the developed as well as developing nations. Almost, 41 million populace are killed in each year due to NCD. The grapping effect is low and numerous nations misunderstood most of the mortality occurred because of infectious agents. NCD are proved to be top-killer in the South-East Asia. The frequently occurred NCDs are cardio-vascular, diabetes, cancer and respiratory disease. The socio-demographic characteristics affects the prevalence of NCD. The life style transition and quality of drinking water induces their occurences. Hence, the present study made an attempt to analyse the association of parameters of drinking water and NCD in the regions of Haveri.

1.3 Problem identification

Fluoride arrives the water bodies through the geological conformation of soil and bedrock. In addition to, dental products, food, fluoride-rich coal combustion, pesticides and pharmaceuticals are the sources of fluoride entering the water resources [23]. Subsequently, it has been conveyed that human beings are consuming excess fluoride by means of drinking water. Almost, ninety percent of fluoride is absorbed through the digestive system existed in the drinking water [24-26]. Human health has been greatly impacted by the excess fluoride [27]. Numerous researches had been conceded out to demonstrate the high fluoride concentration impact on the drinking water. It may causes skeletal disputes on both bones as well as teeth and are more susceptible to pregnant women and children [28-30]. Meanwhile,

the impact of fluoride concentration on human health relies on the water consumption quantity per capita per day. Thus, the fluoride level in the water must be on the basis of average temperature in the regions. Moreover, the reliable data concerning the health impacts related with the TDS consumption in drinking water are scarce. The implication of epidemiological research recommends that low concentrations of TDS in water possess several beneficiaries even though there exists adverse effects.

1.4 Objectives of the study

The objective of the present study are as follows:

- To determine the prevailing status of non-communicable diseases in the Haveri district
- To evaluate the physico-chemical characteristics of different drinking water sources in the Haveri
- To analyse the school and community dental and skeletal fluorosis in the Haveri district.
- To determine the correlation between various drinking water parameters with prevalence of each non-communicable disease in the Haveri.
- To recommend a framework for the achievement of quality life in the Haveri district.

1.5 Research Hypothesis

The research hypotheses constructed for research are as follows,

Hypothesis 1

H1: Physico-chemical characteristics of drinking water varies in the regions of Haveri

$H1_0$: Physico-chemical characteristics of drinking water does not varies in the regions of Haveri

Hypothesis 2

H2: Dental and skeletal fluorosis are prevailed in the school and community of Haveri

$H2_0$: Dental and skeletal fluorosis are not prevailed in the school and community of Haveri

Hypothesis 3

H3: There is significant correlation among drinking water parameters and non-communicable diseases in Haveri

$H3_0$: There is no significant correlation among drinking water parameters and non-communicable diseases in Haveri

1.5 Paper organisation

The paper is organized in the following sequential manner. Section 1 illustrates the brief introduction regarding the impact of drinking water quality in the NCDs. It also depicts the significance of research. Section 2 describes the prevailing scholarly research works related to present research. Section 3 provides the research methodology and the analysis result is presented in section 4. Section 5 illustrates the discussion as well as the limitation of study. Lastly, the section 6 discusses about the conclusion and future recommendation of study.

2. Literature review

The prevailing study [31] demonstrate the association of the fluoridated groundwater and dental fluorosis. There are numerous factors impacting the connotation evaluating the heterogeneity outcomes. The study conducts a meta-analysis of the researches from the year 2007 to 2017. The keywords are searched as per the dental fluorosis which affects the individual of all the ages possessing higher prevalence on the basis of the environmental factors likely dental carries, gender, diet and environmental conditions. The outcome of the meta regression analysis reveals that the fluorides existed in the drinking water and additionally temperature impacts the dental fluorosis. The implications also proves that the fluoride negatively impacts the health of the populace in the poorly developed nations. The study recommends the policy tools as well as the technological innovations which would minimise the fluoride levels to the WHO threshold value of <1.5 mg/L.

The conventional study [32] estimates the dental fluorosis prevalence among 6-12 years children and its relationship with the diverse sources of drinking water. The fluoride level are examined under the seventeen villages of Devadurga and Manvi talukas of Karnataka. The

urine samples of kids are examined among the children. A cross-sectional community has been validated for the seventeen villages utilising the structured questionnaire. ODK software has been utilised for the assessment of the demographic details, drinking water sources and dental fluorosis estimation. Their prevalence as well as severity are measured through the urine and water samples. The relationship among the demographic details likely gender, age, fluoride level in urine and water and dental fluorosis are calculated through the regression analysis. The outcome shows that the prevalence of dental fluorosis was 46.0%. Compared to the river water, there is significant correlation of dental fluorosis and supplementary sources of drinking water. The fluoride level in the urine greater than 4 ppm and that of water is less than 1 ppm. The outcome concludes that the dental fluorosis prevailed among 6 to 12 years for the fluoride overexposure in drinking water. Fluoride level in the urine and water identifies the chronic exposure of fluorides and proves that the populace is more prone to chronic fluorosis.

The conventional study [33] analyses the chronic disease of kidney in multi-factorial origin referred to as CKDmfo. It is manifested in the poor and agricultural nations. It is observed to be environmentally induced, mediated by occupation and tubulointerstitial disease. The continuous exposure of nephrotoxic agents and other circumstances are requisites of CKDmfo. There are thirty main causative factors and mostly significant is fluoride, which is considered to be main causative agent. The study postulates the potentiality of the fluorides that causes CKDmfo. Also, it examines the interactions and synergistic effects of the geogenic factors significantly, its plausibility and nano-tube formation in the tubular filtrate. Data has been gathered from Sri Lanks and the outcome reveals that the prolonged exposure to the nephrotoxins and association among the elements and deficiencies in the micro-nutrients and anti-oxidants. Therefore, the nanominerals precipitation in the renal tube leads to the generation of CKDmfo. It causes chronic renal failure due to excessive fluoride in the water.

The prevailing study [34] demonstrate the association among the pervasiveness of the dental caries as well as dental fluorosis in Urban Vadodara. A cross-sectional study has been conducted in the four zones of the district. 38 water samples has been directed to the Ecology Society in Gujarat for chemical evaluation to estimate the fluoride levels. The data gathering has been conducted from 2609 participants. It encompasses 449 children and the age group less than 15 years of age. Dean's criteria has been utilised to examine the dental fluorosis as well as dental caries. Chi-square has been applied for statistical evaluations. The prevalence was almost 17.36% in the higher fluoride areas. There are no significant differences among the dental fluorosis in the high and normal fluoride regions. The dental caries are higher in the normal fluoride regions compared to the high fluoride areas. Subsequently, the dental fluorosis are higher in high fluoride regions and there are no statistical differences among them.

The prevailing study [35] proposed that the dental caries which is the most predominant of the NCDs. The surface oriented vulnerability denotes that the surfaces of the same group has similar susceptibility. Alternatively, the susceptible group comprises of occulal surfaces in the first molars and also least susceptible are smooth surfaces of incisors, canine and premolars. Hence, the fluorides existed in the drinking water might impact one group rather than the other groups. The contemporary study examines the relationship among the fluoride levels in the water as well as dental caries in the adults of the modifying tooth susceptibility. The data has been gathered from 2017-2019 which encompasses 1398 stratified samples. The dental caries has been estimated at the surface level. They were categorised into four main groups likely the most susceptibility in the group1 and the least susceptible in the group 4. The dental caries are investigated in each group and the outcomes are generated. The information regarding the fluoride levels and the potential determinants are evaluated. Also, it analyses the behaviour of oral health status and socio-demographic features. Kruskal Wallis and Chi-square were utilised to investigate the association among the fluoride levels and implications of the four groups. The median decayed and filled surfaces are reduced in the surface oriented susceptibility. It

implies that the high fluoride level in the water are related with the low dental caries in adults and it is observed in the surface oriented susceptibility.

In early studies, inverse associations were reported amongst TDS concentrations as well as the frequency of cancer [36], coronary heart ailment [37], arteriosclerotic heart disease [38], and cardiovascular ailment [39]. Total mortality rates were reported to be inversely correlated with TDS levels in drinking-water [40]. It was reported in a summary of a study in Australia that mortality from all categories of ischaemic heart disease and acute myocardial infarction was increased in a community with high levels of soluble solids, calcium, magnesium, sulfate, chloride, fluoride, alkalinity, total hardness, and pH when compared with one in which levels were lower [30]. No attempts were made to relate mortality from cardiovascular disease to other potential confounding factors.

A research in coastal Bangladesh recommended that pregnant women were exposed to salt consumption than double the limits reported by the WHO. This exposure elevated the risk of preeclampsia as well as hypertension [41]. Subsequent research of non-pregnant adults in coastal Bangladesh showed that sodium concentrations in drinking water were strongly associated with blood pressures after controlling for personal, lifestyle, and environmental factors and that changing to a less saline drinking water source reduced blood pressure [42].

2.1 Research gap

The outcomes of an epidemiological research in the Soviet Union reveals the elevation of gall bladder stones and inflammation in the five year period because of the increased reside level in the water. The prevalence might ne varied from region to region or district. Since, the researches lacks the detection of the prominent factors casing NCDs. A review of the literature has observed that there are lack of research studies published in western scientific literature.

3. Methodology

3.1 Study Area

Haveri district is lies in parallels of 14 degree 16 minutes and 15 degree 09 minutes and east longitudinal parallels of 75 degree 01 minutes and 75 degree 49 minutes north, Shimoga and Davanagere to the south, Uttara Kannada to the west, Davanagere and Bellary districts to the east. The district has been alienated into two natural divisions namely the Semi Malnad and Maidan particularly the northern maidan. District Haveri is a part of Central Karnataka Plateau. The district falls under northern transition and hilly agro climatic zones of the State. The taluks of Byadgi, Haveri, Hirekerur, Ranibennur, Savanur and Shiggaon falls under northern transition zone. It aids for fruitful achievement of the present research. The survey is conducted with the support of researcher. The defendants who surveyed for this research are within Haveri in India. This will enhance the significance of the study purpose. Therefore, this makes the data gathering process easier.

3.2 Research Design

The research design is denoted as the structure of the research method to finish the motive of the study [43]. An essential judgment and resolutions in the research design progression is the decision to be made concerning research approach [44]. The process of providing précised and a complete framework on which the research will be processing is denoted as research design. The quantitative method designates the occurrence through congregating numerical unchangeable data which has been evaluated with aid of mathematical approaches. This provides statistics associated questions of when, how, where, what, how much and how many. It incorporates the objective, logic and number stance [45]. The research instrument utilized in the current research is questionnaire which aided to congregate data regarding the lean methodology and its optimization of current study [46]. The quantitative research utilizes survey as well as questionnaire method for the gathering of primary data [47]. Qualitative method provides deep understanding of the research study problem and data of qualitative approach gives a depth to study [48].

The current study utilizes quantitative research methodology for congregating data. The research instrument utilized in this current study is questionnaire. It helps to capture the data regarding the interdisciplinary insights on the analysis of drinking water quality that contributed to the NCDs in the Haveri district. The survey is conducted among the populace of Haveri.

3.3 Sampling method and Participants

The sample size of the research study must be designated carefully to achieve the accurate outcome (Stratton, 2021). The appropriate sample participation will be selected to extent of receiving the material concerning the influence of quality of drinking water that impacts the NCDs in Haveri (Lakens, 2022). The present study applies purposive sampling. It select a sample in accord with the relevant understandings to the research determination. The convinced principles in the assortment of sample lead to the in-depth outcome of the study. The subgroup selection from the whole populace is known as a sample which is categorized into non-probability and probability sampling technique. The probability sampling incorporates an aspect of random selection. It provides equal opportunities to population for being chosen [49]. Few commonly employed probability techniques embrace cluster sampling, stratified sampling, random sampling and systematic sampling whereas non-Probability sampling technique incorporates the diverse samples in a research outlook of subjects rather than random selection. The sampling method involves snowball sampling, purposive sampling, quota sampling and self-selection sampling [50]. The targeted respondents are peoples of Haveri district in India who can provide knowledge regarding the factors impacting the drinking water quality in Haveri.

3.4 Research Instrument

The current study will accumulate data with the aid of structured questionnaire from the peoples of Haveri. The questionnaire method is an easier mode in collecting data. The questionnaire is categorized into two types namely structured questionnaire and unstructured questionnaire. Several interview methods involved in gathering data is categorized into direct interview, indirect interview and in-depth interview. Hence, the present study embrace questionnaire to collect data from the carefully chosen respondents. The survey regarding dental fluorosis are performed in the endemic villages. Drinking water samples will be collected during pre-monsoon and post-monsoon and various physico-chemical parameters were analysed by using standard methods.

3.5 Quantitative analysis

Quantitative analysis is designated as a methodical phenomenon of assembling data and implementing computational, mathematical and statistical approaches [51]. This technique is applied to gather data from respondents and define the outcomes to targeted population [52]. The quantitative approach congregated data from forthcoming and conservative management personnel with the aid of sampling tools and providing online survey and polls etc. The consequence of the method is resolute numerically. The numerical values are construed and also identify the upcoming research along with appropriate changes. The quantitative data analysis method is used for current study and analysed data which has been gathered using a structured questionnaire from sample respondents. The data are recorded utilizing Excel sheet for revealing study variables. The software tool referred to as SPSS and it is utilized for analysing the research variable in Excel sheet. The outcome of the study is estimated utilising five approaches known as ANOVA, Correlation and Frequency.

The assumed techniques are employed to detect the data and validate the connotation amongst the variables of the present research. The outcome of the study constructs reveals the mode of interpretation. It also recommends the growth of further researches. SPSS software aids to derive the outcome of the present research. It will be effective for documenting the constructs. Figure 1 illustrates the research framework of the present study. The tables and figure reveals

the statistical results of the various analysis such as ANOVA, regression and correlation. The tests are conducted to evaluate the hypothesis of the current research.

SPSS software is a set of software programs which analyses and studies the scientific information that is data relevant to research purposes and social science. This software provides the visual environment in a fast manner that covers both complex and smallest models. Surveys, market research, data mining, education institutions, industries and other fields use the data collected from SPSS. It is popular software because of some common features like user manual is well-documented, easy to understand the instruction language and simplicity. The fundamental functionalities provided in SPSS is a statistical program intended for quantitative data analysis, which includes bivariate statistics, cross-tabulation and frequencies, text analysis and modeller programming for the survey. Compare to other statistical tool data analysing using SPSS require less time which resultant in fast outcomes.

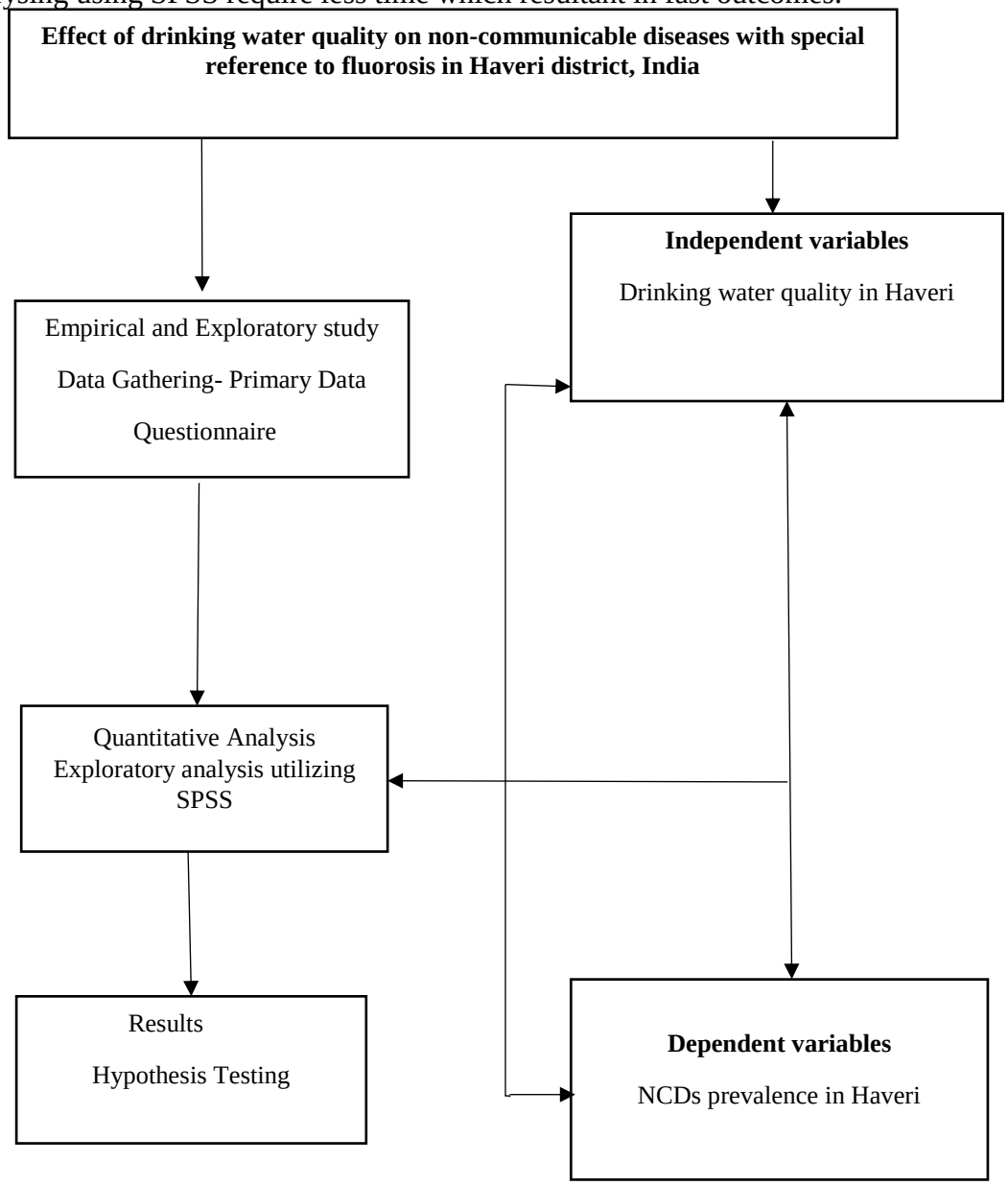

Figure 1 Research Design

The data analysis conducted are in the method of deep evaluation and statistical analysis. To generate appropriate result, the set of data are conducted resourcefully and SPSS can also deal with a large set of data along with various formats. This finds the problem of the study and

generate a solution in statistical form. Therefore, the present study will apply SPSS software to study and analyse the test hypothesis of the research.

4. Results

4.1 Statistical analysis

Hypothesis 1

H1: Physico-chemical characteristics of drinking water varies in the regions of Haveri

$H1_0$: Physico-chemical characteristics of drinking water does not varies in the regions of Haveri

The physico chemical factors of the drinking water from various regions are evaluated and demonstrated below for the pre- and post-monsoon regions in Haveri.

Table 1 Physico-chemical characteristics of drinking water for the month of july

S. No	Villages	Colour (Hezen)	Odour	Taste	Turbidity	Hydrogen Ion Concentration (pH)	Electric Conductivity (EC)	Total Dissolved Solid (TDS)	Total Hardness (TH)	Total Suspended Solids
1	**Gangapur**	0.5	Agreeable	Agreeable	0.7	7.22	1580	990	574	Nil
2	**Govt school gangapur**	0.6	Agreeable	Agreeable	0.7	7.05	660	422	324	Nil
3	**River near gangapur**	0.8	Agreeable	Agreeable	0.6	7.02	1200	760	438	Nil
4	**Kudarihal**	0.5	Agreeable	Agreeable	0.7	6.98	1080	660	389	Nil
5	**Haranagiri (near HPS)**	0.5	Agreeable	Agreeable	0.7	7.18	740	460	344	Nil
6	**Haranagiri (Backside)**	0.5	Agreeable	Agreeable	0.7	7.22	1250	790	452	**Nil**
7	**Kuppelur (RD circle)**	0.2	Agreeable	Agreeable	0.3	6.9	160	110	68	Nil
8	**Kuppelur (PHC)**	0.3	Agreeable	Agreeable	0.5	7.1	200	130	118	Nil
9	**Haranagiri (PHC)**	0.4	Agreeable	Agreeable	0.8	7.2	850	440	310	Nil

10	**SheeBasappa Gudagur**	0.8	Agreeable	Agreeable	0.9	7.18	1000	600	430	Nil
11	**Janataplot Gudagur**	0.6	Agreeable	Agreeable	0.8	7.1	920	510	308	Nil
12	**Lingadahalli**	2.1	Agreeable	Agreeable	4.3	7.2	220	130	104	40
13	**Kudrihal (Near HPS)**	0.4	Agreeable	Agreeable	0.6	6.86	980	590	344	NIL

The table 1 demonstrate the colour, odour, taste, turbidity of diverse regions for the pre-monsoon period. Also, it evaluates the total suspended solids and hardness. The liquid purity is measured utilising the APHA color scale and it is referred to as Hazen. The value 0.5 denotes the light yellow. Most of the regions possess colour of 0.2 to 0.8 Hazen which detects the color to be light yellow and hence denotes the poor quality in drinking water. Odour and taste are agreeable in all the regions. The turbidity identifies the presence of particles that are invisible in the naked eye. The optimal value of turbidity is 0.5-0.8. Most of the regions have optimal turbidity. pH (hydrogen ion concentration) of water lies in the range of 6.5-8.5. Due to the environmental factors, the value modifies. The total dissolved solids evaluates the quantity of organic and inorganic solids present in the specific volume of water. The total hardness are measured based on the calcium carbonate concentration. There are no suspended solids present in the drinking water for all the region excluding the Lingadahalli.

Table 2 Physico-chemical characteristics for the month of November

S. No	**Villages**	**Colour (Hezen)**	**Odour**	**Taste**	**Turbidity**	**Hydrogen Ion Concentration (pH)**	**Electric Conductivity (EC)**	**Total Dissolved Solid (TDS)**	**Total Hardness (TH)**	**Total Suspended Solids**
1	**Gangapur**	0.6	Agreeable	Agreeable	0.8	7.15	1520	988	566	Nil
2	**Govt school gangapur**	0.5	Agreeable	Agreeable	0.6	7.02	1150	748	424	Nil
3	**River near gangapur**	0.8	Agreeable	Agreeable	0.9	7.12	690	449	338	Nil
4	**Kudarihal**	0.5	Agreeable	Agreeable	0.8	6.84	1000	650	386	Nil

5	**Haranagiri (near HPS)**	0.6	Agreeable	Agreeable	0.8	7.25	700	455	336	Nil
6	**Haranagiri (Backside)**	0.5	Agreeable	Agreeable	0.6	7.34	1200	780	440	**Nil**
7	**Kuppelur (RD circle)**	0.1	Agreeable	Agreeable	0.2	6.85	150	98	64	Nil
8	**Kuppelur (PHC)**	0.2	Agreeable	Agreeable	0.4	7.1	200	130	118	Nil
9	**Haranagiri (PHC)**	0.4	Agreeable	Agreeable	0.8	7.2	850	440	310	Nil
10	**SheeBasappa Gudagur**	0.8	Agreeable	Agreeable	0.9	7.18	1000	600	430	Nil
11	**Janataplot Gudagur**	0.6	Agreeable	Agreeable	0.8	7.1	920	510	308	Nil
12	**Lingadahalli**	2.1	Agreeable	Agreeable	4.3	7.2	220	130	104	40
13	**Kudrihal (Near HPS)**	0.4	Agreeable	Agreeable	0.6	6.86	980	590	344	NIL

The table 2 demonstrate the colour, odour, taste, turbidity of diverse regions for the post-monsoon period. Also, it evaluates the total suspended solids and hardness. The liquid purity is measured utilising the APHA color scale and it is referred to as Hazen. The value 0.5 denotes the light yellow. Most of the regions possess colour of 0.2 to 0.8 Hazen which detects the color to be light yellow and hence denotes the poor quality in drinking water. Odour and taste are agreeable in all the regions. The turbidity identifies the presence of particles that are invisible in the naked eye. The optimal value of turbidity is 0.5-0.8. Most of the regions have optimal turbidity. pH (hydrogen ion concentration) of water lies in the range of 6.5-8.5. Due to the environmental factors, the value modifies. The total dissolved solids evaluates the quantity of organic and inorganic solids present in the specific volume of water. The total hardness are measured based on the calcium carbonate concentration. There are no suspended solids present in the drinking water excluding Lingadahalli.

From the table 1 and 2, it has been concluded that the physico-chemical characteristics of the drinking water are slightly differs in both the pre-monsoon and post-monsoon period. Hence, the hypothesis 1 has been proved from the above analysis.

Therefore, **H1: Physico-chemical characteristics of drinking water varies in the regions of Haveri** has been proved from the above analysis.

Hypothesis 2:

H2: Dental and skeletal fluorosis are prevailed in the school and community of Haveri

$H2_0$: Dental and skeletal fluorosis are not prevailed in the school and community of Haveri

The dental fluorosis are estimated by means of analysing the school and community populace regarding their status of fluorosis in the regions of Haveri. Five major categories of fluorosis status are estimated and they are as follows:

Table 3 Status and prediction of dental fluorosis

Status	**Prediction**
Normal	Smooth and glossy enamel surface and appear white
Questionable	The enamel shows slight aberrations , occasional spots might be seen
Very mild	It might appear as opaque white areas
Mild	White opacity is more wide-ranging
Moderate	It might show brown stains

Frequency analysis

It is a statistical procedure and utilised for measuring the quantity of the occurrences chosen by the participants. The present research utilises the frequency analysis for estimating the prevalence of dental and skeletal fluorosis in the villages of Haveri.

Table 4 Frequency analysis

		F	%	V (%)	C (%)
Valid	10family	1	16.7	16.7	16.7
	14 family	2	33.3	33.3	50.0
	15 family	1	16.7	16.7	66.7
	25 family	1	16.7	16.7	83.3
	26 family	1	16.7	16.7	100.0
	Total	6	100.0	100.0	

Table 5 Dental and skeletal fluorosis

		F	%	V (%)	C (%)
Valid	No	6	100.0	100.0	100.0

Tables 4 and 5 illustrates the frequency analysis of the dental and skeletal fluorosis in the villages of Haveri. It has been reported that the all 14 family of the Gudagur village are not suffered from any type of fluorosis. In Lingadahalli village, 25 families are examined and revealed that there is no existence of fluorosis. Subsequently, Gangapur village has been investigated and reported that 10 families are not suffering from any type of fluorosis. Meanwhile, Kuppelur village is investigated and reported that 26 family does not suffer from any type of fluorosis. 14 families of Haranagiri village has not been suffered from dental and skeletal fluorosis. 15 families of Kudarihal village has not been suffered from dental and skeletal fluorosis.

Hence, there is no prevalence of dental and skeletal fluorosis in the six chief villages of Haveri. Therefore, null hypothesis is accepted and convert to H2 hypothesis.

$H2_0$: Dental and skeletal fluorosis are not prevailed in the school and community of Haveri has been proved from the above analysis.

Hypothesis 3

$H3_0$: There is no significant correlation among drinking water parameters and non-communicable diseases in Haveri

H3: There is significant correlation among drinking water parameters and non-communicable diseases in Haveri

Chi-square test

It is an effectual technique utilised to demonstrate the association among the categorical variables. The present research utilised the analysis to determine the association among the drinking water parameters and NCD in Haveri

Table 6 Test Statistics	
	Colour (Hezen) and NCD
Chi-Square	3.692[a]
df	6
Sig.	.718
a. 7 cells (100.0%) have predictable regularities less than 5.	

From Table 6, it has been revealed the implication of chi-square analysis. The chi-square value found to be 3.692 and the significant value found to be 0.718. Since, the value is greater than the threshold value of 0.05 which denotes that there is no significant association among the drinking water parameters and NCD in the regions of Haveri. There is no evidence of occurrence of NCD due to variation in the quality of drinking water. Hence, it supports the null hypothesis and controvert the H3 hypothesis.

$H3_0$: There is no significant correlation among drinking water parameters and non-communicable diseases in Haveri has been proved from the above chi-square analysis.

5. Discussions

From analysis of collected data from the participants of the Haveri district, the inference of the study is depicted. The current study's outcome proves that there are variation in the physic-chemical characteristics in the diverse regions of Haveri. The present study state that there is a no evidence of prevalence of dental fluorosis in the Haveri region. The chi-square analysis demonstrates that there is no prominent association of drinking water parameters and NCDs prevalence in Haveri.

The conventional study in Australia [30] demonstrates the mortality due to ischaemic heart ailment as well as acute myocardial infarction has been elevated because of the increased levels of soluble solids, magnesium, calcium, chloride, sulfate, alkalinity, fluoride, total hardness as well as pH. Comparatively, the present research evaluates the physic-chemical characteristics of drinking water in the pre and post-monsoon period in Haveri. Moreover, it detect the association of drinking water parameters and NCD prevalence through the data analysis.

The contemporary study [31] demonstrate the association of the fluoridated groundwater and dental fluorosis. There are abundant factors impacting the connotation evaluating the heterogeneity outcomes. The outcome of the meta regression analysis reveals that the fluorides existed in the drinking water and additionally temperature impacts the dental fluorosis. Similarly, the present study analyses the fluorosis existence in the Haveri district and observed that there is no prevalence of dental and skeletal fluorosis in the regions of Haveri through frequency analysis.

The prevailing study [34] demonstrate the association among the prevalence of the dental caries and dental fluorosis in Urban Vadodara. Chi-square has been applied for statistical evaluations. There are no significant differences among the dental fluorosis in the high and normal fluoride regions. Likewise, the present study articulates the association of drinking water parameters

and NCD in Haveri. From, the chi-square scrutiny, the substantial value greater than 0.05 which proves that there is no significant association of drinking water quality and NCD in Haveri region.

6. Limitations

The present research study has specific drawbacks. The foremost constraints is the examination of drinking water quality in Haveri. Therefore, the outcome lacks generalizability. Even though, the investigation on the dental fluorosis might aid the populace to aware of the association of drinking water quality and NCD occurrence. It will help to signify the quality of drinking water and the associated diseases caused by them.

7. Conclusion

NCDs likely heart disease, cancer and Fluorosis exemplify an urgent as well as develops global health emergency. NCDs are a precarious challenge in the world. The previous studies does not have the sufficient information to evaluate relationship between water quality and NCD's. The present study demonstrate a correlation amongst environmental factor such as water quality and NCDs. Moreover, it analyses the chief regions of Haveri and identifies the physic-chemical characteristics of drinking water. The characteristics such as color, odour, taste and turbidity are examined in both the pre as well as post monsoon period. There is variation in the physico-chemical characteristics of drinking water. Then, the prevalence of dental and skeletal fluorosis are investigated which evidents that there is no existence of fluorosis in the regions of Haveri. Subsequently, the association of NCD and drinking water parameters analysed and revealed that there is no noteworthy association among them in the Haveri district. Therefore, the study exhibits the novel strategies for the mitigation of the Fluorosis through the high quality drinking water. The study recommends the Government to take necessary action to evaluate the factors impacting the quality water and generates a healthy environment to the respective populace. The study made an attempt to bring a quality health status to future generation.

References

[1] P. Li and J. Wu, "Drinking water quality and public health," *Exposure and Health,* vol. 11, pp. 73-79, 2019.

[2] X. Wen, F. Chen, Y. Lin, H. Zhu, F. Yuan, D. Kuang, *et al.*, "Microbial indicators and their use for monitoring drinking water quality—A review," *Sustainability,* vol. 12, p. 2249, 2020.

[3] M. Serajuddin, M. A. Chowdhury, M. M. Haque, and M. E. Haque, "Using turbidity to determine total suspended solids in an urban stream: a case study," in *Proceedings of the 2nd International Conference on Water and Environmental Engineering, Dhaka*, 2019, pp. 19-22.

[4] Y. Perrin, D. Bouchon, V. Delafont, L. Moulin, and Y. Héchard, "Microbiome of drinking water: A full-scale spatio-temporal study to monitor water quality in the Paris distribution system," *Water Research*, vol. 149, pp. 375-385, 2019.

[5] Y. Ji, J. Wu, Y. Wang, V. Elumalai, and T. Subramani, "Seasonal variation of drinking water quality and human health risk assessment in Hancheng City of Guanzhong Plain, China," *Exposure and health*, vol. 12, pp. 469-485, 2020.

[6] M. B. Addisie, "Evaluating drinking water quality using water quality parameters and esthetic attributes," *Air, Soil and Water Research,* vol. 15, p. 11786221221075005, 2022.

[7] M. J. Abzug, H. L. Keyserling, M. L. Lee, M. J. Levin, and H. A. Rotbart, "Neonatal enterovirus infection: virology, serology, and effects of intravenous immune globulin," *Clinical Infectious Diseases,* vol. 20, pp. 1201-1206, 1995.

[8] W. H. Organization, *Food safety issues associated with products from aquaculture: report of a joint FAO/NACA/WHO study group* vol. 883: World Health Organization, 1999.
[9] S. J. Wimalawansa, "Escalating chronic kidney diseases of multi-factorial origin (CKD-mfo) in Sri Lanka: causes, solutions, and recommendations—update and responses," *Environmental health and preventive medicine,* vol. 20, pp. 152-157, 2015.
[10] S. Pocock, A. Shaper, D. Cook, R. Packham, R. Lacey, P. Powell, *et al.*, "British Regional Heart Study: geographic variations in cardiovascular mortality, and the role of water quality," *Br Med J,* vol. 280, pp. 1243-1249, 1980.
[11] N. Hara, K. Sakata, M. Nagai, Y. Fujita, T. Hashimoto, and H. Yanagawa, "Statistical analyses on the pattern of food consumption and digestive-tract cancers in Japan," 1985.
[12] P. Stocks, "Incidence of congenital malformations in the regions of England and Wales," *British Journal of Preventive & Social Medicine,* vol. 24, p. 67, 1970.
[13] C. Nerbrand, K. Svärdsudd, J. Ek, and G. Tibblin, "Cardiovascular mortality and morbidity in seven counties in Sweden in relation to water hardness and geological settings: the project: myocardial infarction in mid-Sweden," *European heart journal,* vol. 13, pp. 721-727, 1992.
[14] D. Hewitt, "Geographical variations in the mortality attributed to spina bifida and other congenital malformations," *British Journal of Preventive & Social Medicine,* vol. 17, p. 13, 1963.
[15] W. H. Organization and U. N. C. s. Fund, *Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs*: World Health Organization, 2021.
[16] K. N. Rao and P. S. Latha, "Groundwater quality assessment using water quality index with a special focus on vulnerable tribal region of Eastern Ghats hard rock terrain, Southern India," *Arabian Journal of Geosciences,* vol. 12, p. 267, 2019.
[17] S. J. Wimalawansa, "Escalating chronic kidney diseases of multi-factorial origin in Sri Lanka: causes, solutions, and recommendations," *Environmental health and preventive medicine,* vol. 19, pp. 375-394, 2014.
[18] A. Budreviciute, S. Damiati, D. K. Sabir, and R. Kodzius, "Management and prevention strategies for non-communicable diseases (NCDs) and their risk factors," *Frontiers in public health,* vol. 8, p. 574111, 2020.
[19] Y. Wang and J. Wang, "Modelling and prediction of global non-communicable diseases," *BMC public health,* vol. 20, pp. 1-13, 2020.
[20] N. Akseer, S. Mehta, J. Wigle, R. Chera, Z. Brickman, S. Al-Gashm, *et al.*, "Non-communicable diseases among adolescents: current status, determinants, interventions and policies," *BMC public health,* vol. 20, pp. 1-20, 2020.
[21] F. Luna and V. A. Luyckx, "Why have non-communicable diseases been left behind?," *Asian bioethics review,* vol. 12, pp. 5-25, 2020.
[22] B. B. Finlay and C. Humans, "Are noncommunicable diseases communicable?," *Science,* vol. 367, pp. 250-251, 2020.
[23] T. A. Chandio, M. N. Khan, and A. Sarwar, "Fluoride estimation and its correlation with other physicochemical parameters in drinking water of some areas of Balochistan, Pakistan," *Environmental Monitoring and Assessment,* vol. 187, pp. 1-9, 2015.
[24] M. O. G. Elanbya and A. M. Ramadan, "Fluoride levels in Almadinah Almunawwarah bottled water," *Journal of Taibah University Medical Sciences,* vol. 18, p. 1500, 2023.
[25] C. J. Chuah, H. R. Lye, A. D. Ziegler, S. H. Wood, C. Kongpun, and S. Rajchagool, "Fluoride: a naturally-occurring health hazard in drinking-water resources of Northern Thailand," *Science of the total Environment,* vol. 545, pp. 266-279, 2016.

[26] R. Gautam, N. Bhardwaj, and Y. Saini, "Dental fluorosis—a case study from Nawa tehsil in Nagaur district, Rajasthan (India)," *The Environmentalist,* vol. 31, pp. 401-406, 2011.
[27] M. Yousefi, M. Ghoochani, and A. H. Mahvi, "Health risk assessment to fluoride in drinking water of rural residents living in the Poldasht city, Northwest of Iran," *Ecotoxicology and environmental safety,* vol. 148, pp. 426-430, 2018.
[28] J. Fang, X. Wu, J. Xu, X. Yang, X. Song, G. Wang, *et al.*, "Water management challenges in the context of agricultural intensification and endemic fluorosis: the case of Yuanmou County," *Ecohealth,* vol. 8, pp. 444-455, 2011.
[29] B. Jianmin, W. Yu, and Z. Juan, "Arsenic and fluorine in groundwater in western Jilin Province, China: occurrence and health risk assessment," *Natural Hazards,* vol. 77, pp. 1903-1914, 2015.
[30] M. G. McGrady, R. P. Ellwood, P. Srisilapanan, N. Korwanich, H. V. Worthington, and I. A. Pretty, "Dental fluorosis in populations from Chiang Mai, Thailand with different fluoride exposures–Paper 1: assessing fluorosis risk, predictors of fluorosis and the potential role of food preparation," *BMC Oral Health,* vol. 12, pp. 1-12, 2012.
[31] M. Akuno, G. Nocella, E. Milia, and L. Gutierrez, "Factors influencing the relationship between fluoride in drinking water and dental fluorosis: a ten-year systematic review and meta-analysis," *Journal of water and health,* vol. 17, pp. 845-862, 2019.
[32] U. V. Prasad, P. Vastrad, M. J. Barvaliya, R. Kirte, S. K. Ray, T. Chakma, *et al.*, "A community-based study of dental fluorosis in rural children (6–12 years) from an aspirational district in Karnataka, India," *Frontiers in Public Health,* vol. 11, p. 1110777, 2023.
[33] S. J. Wimalawansa, "Does fluoride cause the mysterious chronic kidney disease of multifactorial origin?," *Environmental Geochemistry and Health,* vol. 42, pp. 3035-3057, 2020.
[34] S. V. Patel, R. D. Khokhariya, J. Rathod, D. G. Chatterji, and J. Patel, "Prevalence of dental fluorosis and dental caries among people consuming water in urban Vadodara: A cross-sectional study," *Environmental Disease,* vol. 8, pp. 1-6, 2023.
[35] L. Stangvaltaite-Mouhat, A. Puriene, I. Stankeviciene, and J. Aleksejuniene, "Fluoride in the drinking water and dental caries experience by tooth surface susceptibility among adults," *BMC Oral Health,* vol. 21, pp. 1-9, 2021.
[36] A. C. Burton and J. F. Cornhill, "Correlation of cancer death rates with altitude and with the quality of water supply of the 100 largest cities in the United States," *Journal of Toxicology and Environmental Health, Part A Current Issues,* vol. 3, pp. 465-478, 1977.
[37] H. A. Schroeder, "Relation between mortality from cardiovascular disease and treated water supplies: variations in states and 163 largest municipalities of the United States," *Journal of the American Medical Association,* vol. 172, pp. 1902-1908, 1960.
[38] H. A. Schroeder, "Municipal drinking water and cardiovascular death rates," *Jama,* vol. 195, pp. 81-85, 1966.
[39] G. F. Craun and L. J. McCabe, "Problems associated with metals in drinking water," *Journal-American Water Works Association,* vol. 67, pp. 593-599, 1975.
[40] M. Crawford, M. Gardner, and J. Morris, "Mortality and hardness of water," *Lancet (London, England),* vol. 1, p. 1092, 1968.
[41] A. E. Khan, P. F. D. Scheelbeek, A. B. Shilpi, Q. Chan, S. K. Mojumder, A. Rahman, *et al.*, "Salinity in drinking water and the risk of (pre) eclampsia and gestational hypertension in coastal Bangladesh: a case-control study," *PLoS One,* vol. 9, p. e108715, 2014.

[42] P. F. Scheelbeek, M. A. Chowdhury, A. Haines, D. S. Alam, M. A. Hoque, A. P. Butler, *et al.*, "Drinking water salinity and raised blood pressure: evidence from a cohort study in coastal Bangladesh," *Environmental health perspectives*, vol. 125, p. 057007, 2017.
[43] B. M. Asenahabi, "Basics of research design: A guide to selecting appropriate research design," *International Journal of Contemporary Applied Researches*, vol. 6, pp. 76-89, 2019.
[44] K. J. Sileyew, *Research design and methodology*: IntechOpen Rijeka, 2019.
[45] N. Baur, "Linearity vs. Circularity? On Some Common Misconceptions on the Differences in the Research Process in Qualitative and Quantitative Research."
[46] H. K. Mohajan, "Quantitative research: A successful investigation in natural and social sciences," *Journal of Economic Development, Environment and People*, vol. 9, pp. 50-79, 2020.
[47] L. Sürücü and A. MASLAKÇI, "Validity and reliability in quantitative research," *Business & Management Studies: An International Journal*, vol. 8, pp. 2694-2726, 2020.
[48] S. Dawadi, S. Shrestha, and R. A. Giri, "Mixed-methods research: A discussion on its types, challenges, and criticisms," *Journal of Practical Studies in Education*, vol. 2, pp. 25-36, 2021.
[49] S. B. Fowler and V. Lapp, "Sample size in quantitative research: Sample size will affect the significance of your research," *American Nurse Today*, vol. 14, pp. 61-63, 2019.
[50] R. Adhikari, C. Kydonaki, J. Lawrie, M. O'Reilly, B. Ballantyne, J. Whitehorn, *et al.*, "A mixed-methods feasibility study to assess the acceptability and applicability of immersive virtual reality sepsis game as an adjunct to nursing education," *Nurse education today*, vol. 103, p. 104944, 2021.
[51] Y. M. Jung, "Data analysis in quantitative research," 2019.
[52] H. Dzwigol, "Innovation in marketing research: quantitative and qualitative analysis," 2020.