Poll Res. 39 (1) : 78-86 (2020)

ISSN 0257–8050

PREVALENCE OF WATER BORNE DISEASES AMONG MARBLE MINE WORKERS IN CERTAIN AREAS OF UDAIPUR DISTRICT

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(Received 1 September, 2019; accepted 3 October, 2019)

ABSTRACT

The current study was conducted to investigate prevalence of water borne diseases among marble mine workers in marble mining hubs of Udaipur district. Water samples were collected from clusters of marble mines (Lakhawali, Daroli, Undithal, Odwas). The samples were analyzed for various physico-chemical parameters like pH, alkalinity, TDS, electric conductivity, hardness, nitrates and phosphates. The result of water quality parameters were compared with the BIS and WHO standards, suitable for drinking and domestic purpose. Along with this analysis Primary health centre (PHC) data were also collected from that particular area. Results reveal that some of water quality parameters were above desirable limit and the degraded water quality causes many health problems and thus prevalence of certain diseases like malaria, dysentery was common. The data obtained from PHCs showed that skin diseases, Urinary tract infection (UTI), fever of unknown disease (PUO), diarrhoea were most common disease among mine workers PHC data were also confirmed through personal interview from mine workers. Workers interviewed admitted that water they are using for drinking purpose is not as safe as it should be.

KEY WORDS : Water borne diseases, Mining, Workers, Water quality, Primary health centre.

INTRODUCTION

Mining plays vital role in economic growth in region under investigation; however most of the mining activities have a harmful impact on various environmental factors like air, water and soil. Out of all water is key component which is affected from anthropogenic mining activities. All types of mining disrupt groundwater flow, which in turn can possibly affect surface waters that are in hydraulic continuity with the affected groundwater systems (Choubey, 1991). Mining activities have often caused releases of contaminants or hazardous constituents to the natural water environment, and its effect may be manifested throughout the mine life cycle (Bell *et al*., 2000).

On one gang saw on an average 20-40 tone of marble is processed daily. During operation water is continuously sprinkled on the block to reduce the heat generation. The water requirement is fulfilled by processors through water tankers. Average water loss per day is 1000 litres. Approximately 1000-5000 kilowatt of electricity is required per day on each gang saw to process the block. The marble blocks processed on gang saw results in 30% waste generation.

Udaipur district is well known marble mining hub in the national and international scenario. The natural occurrence of marble at study area (Lakhawali, Daroli, Undithal, Odwas) and its commercial exploitation potentially threatens to local ground and surface water resources due to the leachete from the marble containing waste. Marble waste not only alters the water quality but also cuases water borne diseases among mine workers either directly or indirectly. The objective of this study is to investigate the possibility of adverse effects of marble mining on water quality around the mentioned study area and to characterize the extent and nature of contamination in water as it potentially relates to the marble mine activities. This study will also reveal diseases among workers

caused by anthropogenic mining waste.

STUDY AREA

Rajasthan is the richest state in India with special reference to marble deposits both in quality and quantity. The state is most important centre (Mandi) of marble processing in the country with about 95% of the total processing units. Rajasthan possesses large reserves of about 1100 million tons (M.T) of good quality marble. The important marble deposits in Udaipur district are Babarmal, Devimata (Pink), Rishabdev, Odwas, Masaron Ki Obri, (Green), Darauli, Tidi, Jaspura, Paduna, Manpur, Lohagarh, Sarvadi, Modi Chipala (White), Kela Kuan (Black).

The Udaipur district is in southern Rajasthan situated between parallels 23°26', 26° 20' north latitudes and 73° 09', 74 °45' east longitude at average altitudes of about 579.4 meter above mean sea level. For the study, three sampling stations (Lakhawali, Daroli, Undithal and Odwas) of Udaipur district were identified. Area under study is having a large number of mines where mechanized and semi mechanized mining operations are carried out with advance techniques and machinery.

MATERIALS AND METHODS

For physico-chemical analysis water samples were taken from open wells, hand pumps, mine pit, tube well, pond. The samples were collected, transported and analyzed as per standard method given in APHA and Jackson for soil and water analysis. Standard methods given in (Maiti, 2011). Determination of various physico-chemical parameters like pH, electrical conductivity, total dissolved solids, alkalinity, hardness, nitrates, phosphates has been analyzed after bringing the samples from the sampling stations to the laboratory using standard methods. To observe the prevalence of diseases among marble mine workers data were collected from anganbaries, dispensaries and primary health centers which were confirmed by personal interview. The frequency of occurrence of diseases reported in three seasons summer, winter and monsoon indicating the prevalence of diseases depending on the season and on water quality during various seasons.

RESULTS AND DISCUSSION

The samples were analyzed for the parameters like pH, alkalinity, TDS, electric conductivity, total hardness, nitrate, phosphate for three seasons summer, winter and monsoon. The results of all parameters observed are summarized in following Tables.

Table 1. Results of different physico-chemical parameters of water samples at various sampling locations (A. Lakhawali, B. Daroli, C. Undithal, D. Odwas)

Table 1. 1A

Sample no.	pH	EC	TDS	Alkalinity	Total Hardness	No3-	Po4
W1	7.6	600	408	224	210	4.43	1.01
W2	6.9	765	479	235	250	1.15	0.4
W3	6.8	1228	820	245	220	3.54	0.5
W4	7	864	1135	330	250	1.55	0.28
W5	7.5	950	628	247	254	1.44	0.45
W6	7.2	765	490	221	290	4.08	0.3
W7	7.8	690	440	250	290	8	1.2
W8	6.8	780	530	460	580	12	1
W9	6.4	1420	968	340	380	1.2	0.8
W10	7	980	640	360	350	3	0.54
W11	7.9	1060	690	250	276	11	0.9
W12	7.4	840	538	240	290	8.5	1.5
W13	7.2	630	410	250	240	3.9	0.08
W14	7	450	300	220	260	2.6	0.42
W15	7.2	950	640	260	230	3.15	0.48
W16	7.2	530	358	360	260	2.86	0.32
W17	7.2	820	529	330	290	1	0.4
W18	7	500	334	280	360	6.8	0.28

pH

In present investigation pH value ranges from minimum 6.3 to maximum 8.4 which are within the permissible limit as shown in Table 1.2 B. The Daroli water had both minimum and maximum pH. The samples collected from the core zone exhibited alkaline nature which can be attributed predominantly to the geological formation in this area. The important geological formation in this area is calcite and dolomite in composition which explains the alkaline pH (Singh *et al.,* 2008). All pH values of the drinking water of the study area reveal basic nature of water. However, higher values of pH haste the scale formation in water heaters and germical potential of chlorine (Mohepatra and Purohit, 2000). Fluctuation of pH on sampling sites is due to mining activity. This fluctuation changes the quality of water and comes out in the form of harmful effects for human health directly or indirectly. Gupta *et al.,* (2017) reported that if the pH is less than 6.5, it discontinues the making of vitamins and minerals in the human body. More

Table 1.2 B

Sample No.	pH	EC	TDS	Alkalinity	Total Hardness	NO_3^-	PO_4
W1	7.1	1380	912	320	240	30.8	0.9
W2	6.3	1690	1130	360	280	38.9	0.04
W3	6.5	900	605	400	200	19.8	0.38
W4	8.4	800	538	290	240	1.6	0.02
W5	7.5	1000	680	300	340	3.8	0.02
W6	7.5	860	576	420	280	3.4	0.04
W7	7.3	1060	710	380	400	68.9	0.09
W8	7.6	1690	1122	360	420	76.1	0.05
W9	7.9	1100	724	360	390	38	0.08
W10	7.2	1420	962	400	490	12	1.12
W11	6.9	830	558	320	360	16.1	0.04
W12	7.5	980	658	410	400	7.1	0.09
W13	6.76	1420	951	360	320	55	0.05
W14	7.32	2000	1345	350	300	60.5	0.05
W15	7.34	867	574	336	310	40	0.04
W16	6.89	601	400	284	308	8	0.07
W17	6.86	768	501	312	360	10	0.05
W18	7.01	650	435	410	350	7	0.06

Table 1. 3C

Sample No.	pH	EC	TDS	Alkalinity	Total Hardness	NO_3-	PO_4
W1	7.6	682	457	360	290	6	0.2
W2	7.42	558	360	230	260	32	0.4
W3	7.05	1130	754	400	340	5.2	0.6
W4	6.92	945	612	220	290	8.5	0.2
W5	6.82	1252	802	320	390	18	0.6
W6	7.23	1006	651	320	400	20	0.4
W7	7.5	824	532	400	420	7.9	0.11
W8	7.6	640	428	290	320	45.6	0.49
W9	7.2	1120	758	440	380	5.6	0.9
W10	7.32	1080	734	390	370	12.1	0.32
W11	7.1	1740	1117	380	390	22.4	0.64
W12	7.4	1220	799	360	370	16.7	0.54
W13	7.5	530	355	360	260	7.2	0.98
W14	7.48	600	400	250	250	28.8	0.32
W15	7.2	1790	1179	430	230	2.6	0.48
W16	7.18	940	619	280	200	9.2	0.62
W17	7	1480	970	370	380	14.6	0.82
W18	7.4	1380	929	340	390	16.2	0.68

than 8.5 pH values cause the taste of water more salty and cause eye irritation and skin disorder.

Electrical conductivity

In the present investigation, the conductivity value ranges between 400 µS/cm to 2000 µS/cm which is much beyond the desirable limits (As shown in Table 1.4 D and 1.2 B). Odwas had minimum and Daroli had maximum EC. The samples collected from marble mining area discerned higher electric conductivity values are attributed to the excessive input of salts and silts (Ushamalini *et al.,* 2007). Similar results founded by Maleki *et al.,* (2013) in a study on environmental effects of mining from Qorveh city mines. He stated that drinking water containing high EC level not usable for nearby residents of the mining area and also not good for animal health. EC levels too high or too low both may limit survival, growth or reproduction.

Total dissolved solids

In the present study the values of TDS found between minimum 270 mg/L at Odwas (Table 1.4 D) to maximum 1345 mg/L at Daroli (Table 1.2 B) vividly indicating high mineralization in the area. According to WHO, the TDS value of groundwater should be 500 mg/L. Most of the samples analyzed were found above the maximum permissible limit. It is reported that high TDS content limits the use of ground water for any purpose (Nordstrom, 1987). Higher value of TDS may attribute to the waste from cutting the slurry generated during the processing of marble blocks which contaminates the local water systems (Mohan *et al.,* 2000). The marble slurry generated during the cutting of marble block is responsible for the higher TDS in mine pit wastes as well. High concentration of TDS in ground water may also be attributed to variation in geochemical process and the impact of mining and anthropogenic activities (Mohan *et al.,* 2000).

Table 1.4 D.

Sample no.	pH	EC	TDS	Alkalinity	Total Hardness	NO_3^-	PO_4
W1	6.9	400	270	330	300	36.8	0.79
W2	7.5	900	600	340	240	16.8	0.28
W3	7.3	650	410	260	180	38.1	0.48
W4	8.2	790	530	280	290	14.8	0.62
W5	7.9	780	529	260	300	3.6	0.38
W6	6.8	1120	759	410	240	50.1	0.94
W7	7.6	730	480	320	300	56.8	0.5
W8	7.4	1504	1000	340	340	28.9	0.42
W9	7.68	696	468	220	250	50.2	0.49
W10	7.9	810	532	400	360	38.4	0.32
W11	8	940	609	390	410	6.2	0.92
W12	7.2	980	660	390	390	46.8	0.88
W13	7.66	693	462	240	330	49.5	0.3
W14	7.29	1402	924	380	290	20	0.2
W15	7.63	407	280	170	200	41	0.4
W16	7.68	775	500	410	440	33.5	0.2
W17	7.84	868	568	380	310	1.5	0.8
W18	6.81	1395	912	400	280	47	0.8

Table 2. Primary Health Centre data

S. No.	Name of Disease	A W	A S	A R	B W	B S	B R	C W	C S	C R	D W	D S	D R
1	Skin Diseases	185	190	195	25	30	35	61	50	40	35	29	42
2	Diarrhoea	80	90	85	16	18	19	52	55	60	108	113	95
3	PUO	82	80	75	23	20	25	425	320	440	75	96	82
4	UTI	22	24	30	2	10	5	5	11	8	114	123	105
5	Abdominal Pain	204	205	179	25	27	35	124	128	130	86	109	97

A- Lakhawali, B- Daroli, C- Undithal, D- Odwas
W- Winter, S- Summer, R-Rainy

However TDS concentration above the permissible limit (1500 ppm) causes gastrointestinal irritation (Joseph, 2001). The study also clearly indicates that mine water contains more minerals and a considerable amount of marble dust. High values of TDS in groundwater are generally not harmful to human beings, but a high concentration of these may affect persons who are suffering from kidney and heart diseases. Water containing high dissolved solids may cause laxative or constipation effects (Sasikaran *et al.*, 2012).

Alkalinity

Alkalinity in the analyzed samples ranges from minimum 170 mg/L at Odwas (Table 1.4 D) to maximum 460 mg/L at Lakhawali (Table 1.1 A) and statistical data obtained gave highly significant results during this analytical procedure. Most of the samples were found to above the desirable limit. High alkalinity of water samples indicates contribution of marble mining and processing for these sources. Butler (2018) stated that negative side effects of alkalinity includes the lowering of natural stomach acidity, which helps kill bacteria and expel other undesirable pathogens from entering your bloodstream. Additionally, an overall excess of alkalinity in the body may cause gastrointestinal issues and skin irritations. We can also see the same correlation in figure A to D wherein high alkalinity caused skin diseases and abdominal problems.

Total hardness

The total hardness values in the study area ranges between 200 mg/L at Odwas (Table 1.4 D) to 580 mg/L (Table 1.1 A) at Lakhawali which are much beyond the maximum permissible limits indicating extremely hard water. The long term consumption of extremely hard water might lead to an increased incident of urolithiosis, anencephaly, parental mortality and certain types of cancer and cardio vascular disorders (Maiti, 2011). The adverse effects of increased hardness leads to many health problems like kidney stones and the heart diseases (Ramaswamy and Rajguru, 1991). Nevertheless, ground water chemistry is controlled by composition of its recharge components as well as by geological and hydro geological variations (Sastry and Rathi, 1988).

Nitrate

In the conducted experiments exhibited nitrate value of water sample for Jaspura, Gogunda and Lakhawali which shows the highly significant results which ranges between 1 mg/L at Lakhawali to 76.1 mg/L at Daroli. The levels of NO_3-N are associated with source availability and regional environmental factors. The present research also indicates high concentration of nitrates which can cause methanemoglobinaemia, gastric cancer, goitre, birth malformations and hypertension as cited by (Schepers, 1984). A study conducted by the

Table 3. Disease and Season wise Patients (Mean ± SD) – Year 2015

Disease	Season			
	Winter	Summer	Rainy	Total
Skin Disease	65.17 ± 60.82	67.00 ± 60.83	61.67 ± 65.55	64.61 ± 58.69
Diarrhea	85.83 ± 77.18	86.67 ± 69.80	82.67 ± 60.16	85.06 ± 65.21
PUO	128.50 ± 147.90	105.83 ± 108.83	126.67 ± 155.75	120.33 ± 131.01
UTI	41.83 ± 47.42	42.67 ± 39.99	41.50 ± 36.94	42.00 ± 39.16
Abdominal Pain	98.33 ± 66.73	95.33 ± 65.94	96.17 ± 54.39	96.61 ± 58.83

Table 4. Correlation between physico-chemical parameters of water

	pH	EC	TDS	Alkalinity	Total Hardness	NO_3^-	PO_4
pH	1						
EC	-0.094666955	1					
TDS	-0.094655508	0.999637	1				
Alkalinity	-0.139778877	0.134454	0.139381	1			
Total Hardness	0.182157546	0.122877	0.125	0.252572	1		
NO_3^-	-0.062449852	0.686007	0.677178	0.09302	0.168533	1	
PO_4	-0.134444794	0.224834	0.227543	0.178168	0.144506	-0.11028	1

Table 5. Correlation between various physico-chemical parameters of water (pH, TDS, Alkalinity, TH, NO_3^- and PO_4 and diseases (skin diseases, Diarrhoea, PUO, UTI, Abdominal pain) 5.1 A- Lakhawali, 5.2 B- Daroli, 5.3 C- Undithal, 5.4 D- Odwas

Table 5. 1 A

	pH	EC	TDS	Alkalinity	Total Hardness	NO_3^-	Po4	Skin Diseases	Diarrhoea	PUO	UTI	Abdominal Pain
pH	1											
EC	0.948011	1										
TDS	0.73856	0.914714	1									
Alkalinity	0.598367	0.31228	-0.09824	1								
Total Hardness	0.801825	0.569974	0.189329	0.958563	1							
NO_3^-	0.853606	0.643453	0.279242	0.928141	0.995722507	1						
PO_4	0.984878	0.87854	0.610588	0.728131	0.893227186	0.930947	1					
Skin Diseases	-0.39736	-0.66874	-0.91215	0.497485	0.229745077	0.13884	-0.23236	1				
Diarrhoea	0.59604	0.309523	-0.10113	0.999996	0.957732491	0.927058	0.726139	0.5	1			
PUO	0.606143	0.827741	0.983892	-0.27456	0.010747921	0.103091	0.45918	-0.97073	-0.27735	1		
UTI	-0.63628	-0.84871	-0.99004	0.237375	-0.049199286	-0.14127	-0.49301	0.960769	0.240192	-0.99926	1	
Abdominal Pain	0.822723	0.96085	0.990867	0.036842	0.320002155	0.406169	0.711799	-0.84856	0.033942	0.950801	-0.962013	1

Table 5.2 B

	pH	EC	TDS	Alkalinity	Total Hardness	NO_3^-	PO_4	Skin Diseases	Diarrhoea	PUO	UTI	Abdominal Pain
pH	1											
EC	0.995112	1										
TDS	0.997652	0.999539	1									
Alkalinity	0.947744	0.974617	0.967368	1								
Total Hardness	0.574991	0.652976	0.629672	0.805963	1							
No3-	0.302496	0.395143	0.367061	0.590774	0.953762	1						
Po4	0.894233	0.84566	0.86148	0.704705	0.147966	-0.15613	1					
Skin Diseases	0.504498	0.416768	0.444183	0.202679	-0.41633	-0.67035	0.837604	1				
Diarrhoea	0.658577	0.581045	0.605495	0.384087	-0.237	-0.51804	0.925747	0.981981	1			
PUO	-0.59186	-0.66856	-0.64567	-0.81808	-0.99978	-0.94732	-0.16847	0.39736	0.216777	1		
UTI	0.988987	0.998768	0.996801	0.984524	0.689749	0.440234	0.818138	0.371154	0.539949	-0.70463	1	
Abdominal Pain	0.194087	0.096264	0.12645	-0.12902	-0.691	-0.87632	0.61265	0.944911	0.866025	0.675845	0.046761	1

National Cancer Institute, indicate that women consuming nitrate-contaminated water face a greater risk of thyroid cancer. A study at the University of Iowa (2015) discovered a link between long-term nitrate exposures from drinking water and increased risks of ovarian and bladder cancer among postmenopausal women.

Phosphate

The phosphate content observed well within desirable limits which ranges from 0.02 mg/L at Daroli (Table 1.2 B) to 1.5 mg/L at Lakhawali (Table 1.1 A). The result of phosphate estimation exhibited a significant value in almost all sampling stations. It has been proposed by scientists world over that mineral levels in different bodies of water have profound effect on the levels of phosphates which ultimately has an adverse impact the overall health of the water and its inhabitants (Majumdar, 2000). High concentration may cause vomiting and diarrhea (As shown in Figure A to D), stimulate secondary hyperthyroidism and bone loss (Singh *et al.*, 2008). Although phosphate is essential element in water but if it is in excess level it gives harmful effect not only for environment, ecological systems but also for human health. The recommended value of phosphorous in drinking water according to EPA is 5 mg/L. Though, in permissible limit it is essential for human health, however, beyond permissible limit it may damage kidney and causes osteoporosis (Slatopolsky *et al.*, 1971).

Our observations and correlation between physic-chemical parameters of water samples and data received from primary health centres, clearly shows that mining discharge from different mining activities effects water quality. Fluctuation in

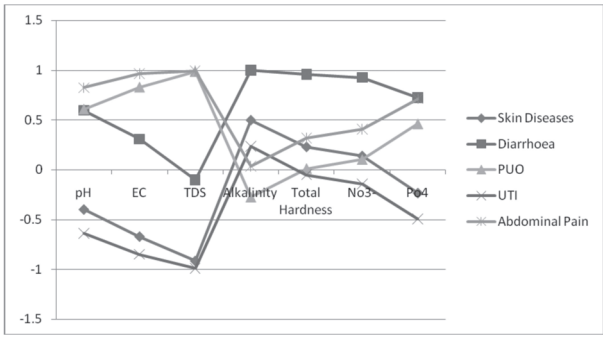

Fig. A

Fig 1. A–D Graphical representation of correlation between physico-chemical parameters of water samples and diseases at different sampling locations Figure- A Lakhawali, B- Daroli, C- Undithal, D- Odwas

different water parameters like TDS, Nitrate, pH, phosphate and total hardness found at sampling sites which causes diseases like diarrhoea, abdominal pain, PUO (fever of unknown disease), skin diseases, UTI (urinary tract infection) (As shown in Table 5 A to D and Figure A to D). Similar diseases were also noticed in both surveys personal questionnaire and datas found from primary health centres (Table 2).

In the present study, the physico-chemical characteristic of water in marble mining area is fairly suitable for drinking purpose. Although the

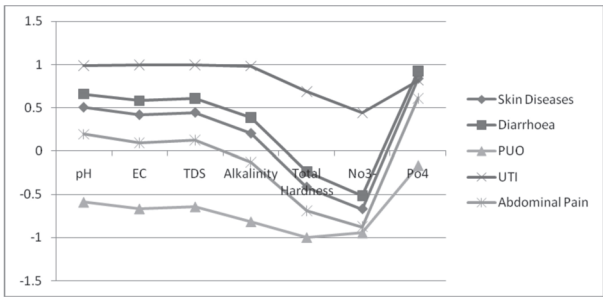

Fig. B

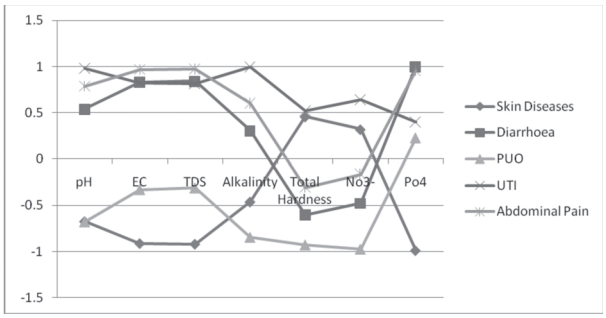

Fig. C

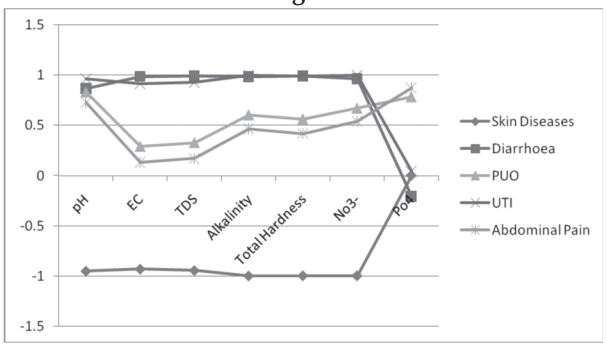

Fig. D

result of few parameters like nitrate, phosphate, total hardness, alkalinity which determine the quality of drinking water are above desirable limits of BIS and WHO standards, however some other parameters like EC, pH, TDS gave no significant

Table 5.3 C

	pH	EC	TDS	Alkalinity	Total Hardness	NO_3^-	PO_4	Skin Diseases	Diarrhoea	PUO	UTI	Abdominal Pain
pH	1											
EC	0.917528	1										
TDS	0.910136	0.999834	1									
Alkalinity	0.966282	0.784196	0.772769	1								
Total Hardness	0.347453	-0.0541	-0.07227	0.57718	1							
NO_3-	0.483632	0.095675	0.077537	0.692694	0.988779	1						
PO_4	0.563621	0.845629	0.855206	0.331927	-0.57874	-0.45042	1					
Skin Diseases	-0.67518	-0.91284	-0.92012	-0.46248	0.457101	0.319106	-0.98987	1				
Diarrhoea	0.539949	0.830138	0.840151	0.305019	-0.60165	-0.47558	0.999597	-0.98544	1			
PUO	-0.67585	-0.327	-0.30975	-0.84283	-0.92595	-0.97197	0.227901	-0.08736	0.255446	1		
UTI	0.981981	0.825841	0.815438	0.99753	0.5184	0.640328	0.39736	-0.52361	0.371154	-0.80296	1	
Abdominal Pain	0.785714	0.96691	0.971395	0.599945	-0.30705	-0.16144	0.953821	-0.9868	0.944911	-0.07509	0.654654	1

Table 5.4 D

	pH	EC	TDS	Alkalinity	Total Hardness	NO_3-	PO_4	Skin Diseases	Diarrhoea	PUO	UTI	Abdominal Pain
pH	1											
EC	0.775557	1										
TDS	0.800106	0.999205	1									
Alkalinity	0.945557	0.938787	0.951774	1								
Total Hardness	0.927774	0.955098	0.966151	0.998705	1							
NO_3-	0.969912	0.90591	0.922071	0.996341	0.990703	1						
PO_4	0.305224	-0.36443	-0.32702	-0.02132	-0.07216	0.064204	1					
Skin Diseases	-0.95178	-0.93183	-0.94555	-0.99981	-0.99751	-0.99783	0.001642	1				
Diarrhoea	0.868507	0.986486	0.992234	0.982544	0.990736	0.96305	-0.20693	-0.97869	1			
PUO	0.831142	0.29357	0.331444	0.604917	0.563621	0.670759	0.78321	-0.62047	0.446226	1		
UTI	0.964452	0.914807	0.930181	0.997949	0.993399	0.999769	0.042728	-0.99902	0.96862	0.654654	1	
Abdominal Pain	0.728499	0.132539	0.171946	0.465884	0.420263	0.539803	0.874712	-0.48321	0.293145	0.986414	0.521575	1

results to adversely affect human health. Finally it is suggested that the concentration of pollutants should be minimized so that the concentration are well below the maximum permissible limit and not much exceeding the desirable limits too in mining areas to protect the health of people in and around the mining area and environment protection is also a primary for sustainable mining. Total pollution or degradation prevention cannot be attained but the important thing is to reduce the effect of pollution and degradation to the nearest minimum.

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