**Table 2:** Water Quality Analysis and their Ranges

| S. No | Parameter | Methodology | Max. permissible limit for drinking water | Desirable limit for drinking water | Range among the 10 samples analyzed | |
|---|---|---|---|---|---|---|
| | | | | | Max | Min |
| 1. | pH | pH meter | No relaxation | 6.5-8.5 | 8 | 7 |
| 2. | EC | Electrical Conductivity meter | 0-2000 µS/cm | 750 µS/cm | 849 | 223 |
| 3. | TDS | TDS Meter. | 2000 mg/l | 500 mg/l | 134 | 565 |
| 4. | TH | EDTA-Titrimetric method | 600mg/l | 300mg/l | 90 | 178 |
| 5. | $Cl^-$ | Argenoto metric method | 1000 mg/l | 250mg/l | 0.3 | 0.7 |
| 6. | $Ca^{2+}$ | EDTA-Titrimetric method | 200 mg/l | 75 mg/l | 11.8 | 44.4 |
| 7. | $Mg^{2+}$ | By Difference | 100 mg/l | 30 mg/l | 2.9 | 26.3 |
| 8. | $NO_3^{2-}$ | Ultraviolet Spectrophotometer method | No relaxation | 45mg/l | 1.0 | 5.3 |
| 9. | $Na^+$ | Flame photometric method | No guidelines | | 0.1 | 31.9 |
| 10. | Biological Parameters i)Total Coliform | Most Probable Number Method | <50 MPN/100ml: Class A (Drinking water after disinfection). >5000 MPN/100ml: Below C After disinfection, no drinking. | | <2 | $2.6x10^5$ Only in Chubi Hand pump |

Out of total analyzed water samples 9 samples were well within the permissible limits as per (APHA, 2012) [15], only one sample from Chubi handpump had bacterial contamination due to shallow aquifer being tapped for drinking purposes in July, 2014 but absent during 2013 and Jan, 2014. An interview with a hydrogeologist working in Leh, it was known that Chubi area is most susceptible to groundwater pollution from nearby soak pits which leaches raw sewage because of shallow aquifer. A striking point to be noted was that only in peak summers the bacterial contamination was noted and bacterial presence was absent in peak winters which indicates a direct point pollution source from nearby soak pits mainly due to tourism boom and waste water discharge of summer times.

*Centralized waste water treatment why adopted by the authorities*: Since 2009, the PHE department of Leh has envisioned this project in collaboration with Tetra-Tech under JNNURM (Jawaharlal Nehru National Urban Renewable Mission) [18]. Through an interview with a soil expert from Leh, it was known that it is impossible to set up the STP (Sewage Treatment Plant)at Skara which is located on the foot of the town that due to people's disposition and influence, as any area nearby a STP is conventionally very smelly. Finally the place being chosen at Agling is understandable as mostly rural migrants and refugees reside here. In spite of the fact that these residents should have a say in this but the authorities finally could procure this land after much deliberation as it is located on the fringes and is a satellite outgrowth of Leh town. Also to set up a cluster of decentralized system requires some space in the midst of residential areas and social convincing for this technology among the locals could take a very long time and in this particular case, the need was dire for setting up a waste water treatment facility as soon as possible.

Topographically also, some places like Leh Old town area and hillock housing areas, below old bus stand are not feasible to set up such plants due to these areas being in mountainous terrain.

Finally, India is a developing country and the standard waste water treatment usually practiced is a centralized STP plant generally monitored by CPCB/SPCB (Central Pollution Control Board/State Pollution Control Board) all over India. Thus the same system is being adopted in Leh town and according to Reach Ladakh paper it is one of the biggest project pegged at 217 crores INR, so highly prestigious if successfully completed, that too at the earnest within the set timeframe.

***Pros and Cons of Centralized waste water treatment in Leh valley:*** *Pro:* General acceptance and adopted by public, as there is assurance of continuum of treatment, that too a third party is doing and the people does not need to worry about sewage [9]. Relatively easier to procure land for setting up the STP as has to be done once rather than squabble several times over many small lands among present housing areas in case of decentralized ones. No special training required to be imparted for the community in management of any such small plants.

*Con:* While on the contrary this system, especially the lifetime of sewage collection pipes is 50-60 years and has high maintenance cost along with large volume of water for gushing through the pipes in order to prevent scaling, is needed. The major concern is even if the collected sewage does not freezes during winters by following precautions like pipes being laid deep below the ground and cotton wool being used for surface ones while the question is, during the treatment at the plant will it not freeze? Added energy and high end technology is needed along with a continuous electricity supply but many arctic central water

systems above ground have failed because of a missing fuse, pump or heater [19].

This region already comes in the high seismic zone IV and is prone to earthquakes [20]. A high hazard and risk is also there of the centralized system during any disaster which can cause havoc in the region putting all surface and groundwater quality at stake but the area already is at risk of groundwater pollution from not having a proper system for sewage treatment.

***Pros and Cons of Decentralized waste water treatment in Leh valley:*** *Pro:* Lesser in cost due to reduction in collection cost as the process is generally onsite or very small distance from waste collection till treatment. More flexible than centralized system as on site technologies can be developed and distributed in free market easily [21].

*Con*: Decentralization is hard to introduce due to conditioning factors (social, economic and environmental). Without effective cooperation by the end user, it is not possible to successfully run and manage such a system. This also needs some space even though little and an enclosed or below the ground along with constant heating is required for smooth functioning, under sub-zero conditions. So, densely populated and hilly terrains of Leh Old town and Maney Tselding are not suitable to have such systems as the later area already had a record of flash floods.

## 6. Conclusion

As massive challenges lie ahead regarding the long term sustainability of a centralized sewage treatment system, there is requirement of diversification in waste-water treatment in Leh town by not depending on this centralized treatment facility solely. One method is promoting the age old traditional sanitation system especially during winters rather than using the wet system as *passive solar technology* had made possible for yearlong functioning of wet sanitation practice in recent times in the region without having freezing pipes. More importantly the region needs to assimilate advanced, cost-effective decentralized systems along with the centralized system in order for tourism promotion and general public cannot be dictated for using dry sanitation only. Alternatives to the flush toilets and sewerage are needed and flush and forget attitude is not working, the faster we realize it, the better [13]. An integrated suite of suitable alternatives would make the sanitation policy more robust.

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