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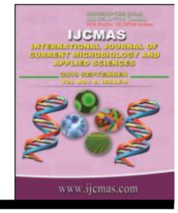

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Impact of Agriculture and Land Use on Ground Water Quality: A Case Study of Ladakh Cold Arid Region

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Water reservoirs are always characterized for drinking water quality. However, in catchments where arable fields dominate, the impact of agriculture on water pollution is still problematic. In Ladakh, recently the fertilization level has decreased drastically due to detrimental impact on soil conditions, mostly for economic reasons as well as lastly getting more awareness on benefits of organic farming towards maintaining indigenous traditional knowledge/ methodologies. However, almost few villages still apply fertilizers as starter dose to boost the crop emergence as well as adding un-decomposed manure cum night soil in their field due to declining trend in livestock size per household. In order to evaluate the impact of agriculture on water quality in a water reservoir with a high proportion of arable fields adjoining to reservoir were monitored. Present study was carried out in Gangles Gompa village situated 5 km upper side of Leh market with stone meant to provide drinking water for 40% population of Leh city. The aim of the study were to assess (1) the impact of agriculture land on groundwater, and running water quality and (2) impact of drains on aquatic animals and human health.

Introduction

Water reservoirs for drinking purpose are expected to be characterized by good water quality. However, in catchments area where arable fields dominate, the impact of agriculture on water pollution becomes important. Eutrophication is a key factor causing degradation of water quality, which restricts its use. Recently, agriculture is recognized as a major source of water pollution, (Billen *et al.*, 2013; Fowler *et al.*, 2013). Degradation of soil and water from agriculture occur due to residues of used chemicals (pesticides), emission of ammonium, methane or sulfide from livestock production, and livestock manures. One of the most problematic is nitrogen and phosphorus leaching from arable fields to groundwater and surface water as a result of higher amounts of these nutrients applied in natural and mineral fertilizers compared to plant requirements or supplied in adverse conditions (Billen *et al.*, 2013; Kyllmar *et al.*,2014 b). The major excessive N inputs from agriculture have been identified as a major contributor to stream N loadings (Boyer *et al.*, 2002, Hatano *et al.*, 2005; Garnier *et al.*, 2010). Nutrient leaching depends on several factors: primarily fertilization level, type, and timing of fertilizer application; the method of their application to the soil; properties of soils (i.e., pH, structure and organic matter content), types of crops and their fertilizer requirements; method of cultivation and agronomic practices; and the level of animal production (Bechmann 2014, Kyllmar *et al.*,2014a and 2014(b)). Weather conditions and catchment land use also have a crucial impact on the intensity and quantity of nitrogen leaching (Jiang *et al.*,2014; Yoon 2005; Woli *et al.*,2008).

A key factor in determining plant nutrient uptake is also the availability of micro- and macro-elements in the soil, particularly mass ratios between elements (Cakmak 2005; Fageria 2001; Güsewell *et al.*, 2003; Szczepaniak *et al.*, 2013). An insufficient amount of potassium reduces nitrogen uptake by plants and thereby may increase nitrogen leaching from soil (Lawniczak *et al.*, (2009) and Lawniczak (2011). Also, deficient availability of phosphorus causes decreased plant biomass, even when nitrogen is in an optimal concentration compared to plant requirements (Güsewell 2004. However, relationships between these elements are not well understood in terms of nutrient leaching in agricultural areas.

Nitrogen, in particular the very soluble nitrate, is easily dissolved into the percolating water. Phosphorus is less mobile and reaches surface water due to erosion with the bound soil particles. These different pathways cause a problem with water protection, because elimination of one water pollution source may aggravate another. For example, reduction of fertilization level or one of the elements may not reduce leaching of nutrients as a result of the unfavorable ratio of nutrients in soil. Deficiency of phosphorus or potassium limits the uptake of nitrogen by plants, even when the nitrogen level is sufficient (Lawniczak *et al.*, 2009). This suggests that at a low level of fertilization due to shortage of potassium and phosphorus, there may occur loss of nitrogen, which results in water and soil pollution. This issue may concern two thirds of the world's agricultural land where potassium deficiency occurs (Romheld and Kirkby 2010).

The necessity of measures to reduce the negative impact of agriculture on water quality results from the provisions of European Commission Council Directive 91/676/EEC (i.e., the Nitrate Directive) concerning the protection of waters against pollution caused by nitrates from agricultural sources. In Poland, these activities are obligated in the designated Nitrate Vulnerable Zones (NVZs), which were introduced as special actions based on local law. However, nitrogen pollutants affect more areas (Iital *et al.*, 2014; Rozemeijer *et al.*, 2014; Wendland *et al.*, 2009), even where the nitrate level is exceeded occasionally. Particularly, they should be focused on protected areas that are characterized by a large proportion of agricultural land.

The Wielkopolska region is one of the most developed agricultural areas in Poland. A high proportion of agricultural land cover types in the region carry the risk of water pollution. The fertilization level in this part of Poland was always higher than in other parts of Poland (GUS 1952–2013). However, recently, these differences significantly decreased and application of fertilizers is at the level recommended in terms of water and soil protection against pollution from agricultural sources (Codex of Good Agricultural Practice 2004).

In order to recognize the impact of agriculture, particularly supply of fertilizers, on water quality in the protected area, complex monitoring has been applied. The study was carried out in Wielkopolska National Park and its buffer zone, which are also protected as Natura 2000 sites. In this area, open water bodies are characterized by poor water quality (Lawniczak unpublished results). Knowledge of the impact of agriculture on groundwater quality, particularly the most problematic non-point sources, is crucial for a proper protection strategy for this area.

The aim of the study were (1) to assess the impact of agriculture, particularly fertilization and un-decomposed manure, on quality of groundwater and running water; (2) Induces of drainage of water on aquatic animals and human health (3) to provide recommendations and suggestions for conserving valuable water reservoir.

Study area

The study was carried out in the Gangles-Gompa dug-well water reservoirs, located in the Gompa village, about 5 km from Leh main bazaar at an elevation in between 34°12' 77°35' to 34°11' 77°35'. The dug-well was established around in 1980 by PHE department drinking water supply for Leh city. The concept of this dug well is to collect the discharge getting from spring and deliver to public for drinking purpose and to reduce the human impact as well as animal on the pond and also improve the efficiency of pond protection of fencing were also done.

Currently, the pond fencing was damages from one side, the whole concept behind this dug well get reversed in which dogs and cow dropping, instead of spring water, drainage of agriculture as well as 50% chances of septic water also enters in this dug well by the observation of farmers in this area as well our observation in field. This water level of dug well remains low in winter season. Once the irrigation started in summer the pond water level started rising.

As the chances of leaching and seepage from the agriculture as well as from septic tanks of habitats in this dug well is around 90% due to high elevation of field and habitats then dug well. Still 40% of water is delivered by PHE to Leh city in which following areas were covered, Part of Gonpa, Sankar, Lamdon, Chupi, Zangsti etc are still cover through this dug well for drinking purpose.

Materials and Methods

The study was carried out during year 2018-19 as per questions raised by Gompa village farmers that lots of small worms and sometime received dead fish from their drinking water have been observed from tap water supply. On report, main water reservoir was observed accordingly and water testing carried out with the help of TDS, pH meter, using VSI water testing kit in which physical property of water quality were tested per the ecological status of dug well.

Judge the following data provided by Department of Agriculture on utilization of chemical fertilizer use in Leh District (unit quintals) may be the one cause of water pollution.

Year	Urea	DAP	MOP	Total
1990	3537	1795	37	5369
1991	4172	2157	52	6384
1992	4369	2237	90	6696
1993	3544	592	33	4171
1994	3741	1034	13	4788
1995	5814	1809	19	7642
1996	3567	1345	1	5913
1997	4310	1563	106	5979
1998	7055	2830	55	9940
1999	5542	2352	8	7902
2000	3693	1894	Nil	5587
2001	4003	2035	71	6109
2002	3756	2245	32	6033
2003	2296	1842	Nil	4138
2004	3570	2430	68	6068
2005	3537	2566	10	6113
2006	3710	2626	8	6344
2007	3748	2965	1	6714
2008	3660	2719	75	6454
2009	4058	3187	119	7364
2010	3735	3341	165	7241
2011	3547	3177	10	6734
2012	3689	3489	142	7320
2013	3606	3378	107	7091
2014	3498	2922	83	6503
2015	3634	2705	81	6420
2016	3100	3000	49	6149
2017	3100	3099	25	6224
2018	2884	2296	147	5327

In initial stage this dug well is only design for harvest spring water still today it supply drinking water in 40% of Leh area includes (Gompa, Chubi, Khakshal, Lamdon, Police Thana). But during summer and during irrigation period the water level reach up to half of dug well as compared to normal water level in winter. During observation it was noticed that most of the area under arable fields in the catchment. Impact of agriculture land and habitats which is located at higher elevation compared to pond is positive and 60% Algae blossom in dug well. Shirley Sharpe mention in aquarium that nitrate levels as low as 10 ppm will promote algae growth. Algae blooms in newly setup well due to elevated nitrate levels. Similarly, Dolma *et al.*, 2015 reported in Baseline Study of Drinking Water Quality–A Case of Leh Town, Ladakh (J&K), India it was observed the nitrate content of water samples in the study area was varied from 0 mg/l to 1.00 mg/l with mean value of 0.16 mg/l during pre-monsoon and between 0 mg/l to 0.97 mg/l with mean value of 0.16 during post monsoon. Its shows that in the study area the nitrate concentration might be within 10 ppm when the growth of algae if we observed. Algal growth decline DO level causing mortality of fishes and contaminate further. As per, farmer observation they found small worms and dead fishes in their drinking water its shows the DO level of water is low in that water. Water is cloudy with moderate turbidity within the range of 0-50 NTU during winter and after irrigation.

Eutrophication is a key factor causing degradation of water quality of dug well. In these area farmers using un-decomposed manure and fertilizer for substitute, so definitely 80% chances of nitrate, nutrients, *E-coli* presence in water through leaching as well as seepage. People of the surrounding villages were interviewed and water testing analysis were took placed following symptoms in water bodies was observed.

Water moving through soil carries many soluble ions with it in the process of leaching which is a natural phenomenon occurring following rainfall or irrigation exceeds the field capacity of soil. Since nitrate is soluble in water and mobile in the soil, it readily moves with any water passing beyond the root zone. Given sufficient time and water, nitrate may eventually reach groundwater and running water through our drinking tape water.

Results and Discussion

The impact of agriculture on water quality is definitely acknowledged due to increase rate of nutrient supply in dug well not directly but through seepage or leakages during irrigation period boost the algae population in dug well. Keeping above observations in mind the following recommendations and suggestions are very important to keep the water around to the safe limit for drinking purpose.

The desirable limits of nitrates in nature are below 5ppm which generally, a very low nitrates. In fresh drinking water, nitrates should be kept below 10ppm to reduce algae growth as well as reduce prevent health hazard. Similarly, for aquariums, nitrates should be kept below 50 ppm at all times, preferably below 25 ppm.

It is regulated in drinking water primarily because excess levels can cause methemoglobinemia, or "blue baby" disease. In this area children are facing problem of low Hb and pregnant women also facing such problem.

It was also observed that in Leh area chemical fertilizer utilization remain varies from 4171 to 9940 quintals from1998 to 2018 and more chances of water pollution in this area due to vegetable grower.

Water quality is cloudy, opaque, and muddy taste. Its changes its color during winter and after irrigation in summer. Its range varies from 0-50NTU. As for drinking purpose it should be less then 5NTU.So proper filter unit is must this areas.

Before supply water to public, nitrates levels should be checked every fortnightly so, you know if the levels are unusually high in your as per the particular water source. If nitrates are above 10 ppm, one should consider other water sources that are free of nitrates.

As the Dug-well should be well protected if human consumption is concerned and should be covered with lid and walls to **r**educe lighting where there is direct sunlight for even part of the day. Sunlight can, and will, sometimes provide desired level of temperature at high altitude to promote algae growth. When using artificial light, make sure it is not stronger than necessary and is not on more than about eight hours each day.

Drain water reservoir

The single most important way to avoid algae is to perform regular water changes through drains at least 10 to 15% water should change.

Regular water testing of dug well before supply to public; and also, to check nitrates level sometime water sources have high elevated nitrates.

Clean of dug well

If algae beginning to grow on the, rocks, or other hard surfaces of the well the remove it. Scrape the glass, remove rocks, and scrub them. Vacuum the gravel when you perform water changes. Frequently chlorination is must.

Fig.1

Fig.2

Table.1

S.No.	Parameter	Max. permissible limit for drinking water	Desirable limit	Observed Data	Remark
1	Turbidity	< 5NTU	< 1NTU	<50NTU	Moderate turbidity
2	Color			Opaque	Due to seepage from agriculture land
3	Odor			Muddy smell	
4	Temperature of water	$<25^0C$	$<10\ ^0C$	27^0C	Exposure of direct sunlight
5	pH		6.6 to 8.4.	5.2	Acid in nature
6.	TDS	2000 mg/l	<500ppm	>250ppm	Slightly high for drinking
7.	Nitrate	<10mg/l	1mg/1	<10ppm	Chances of leaching in dug well after seeing Algae growth

Maintaining algae-eating fish

Keeping Siamese flying fox, otocinclus, or even the common plecostomus, will help reduce some of the algae in the dug well.

Installation of high quality water filtration unit;

Community and policy makers' initiatives to conserve ponds of Ladakh

Water consumption policy is required to be framed to including all stakeholders to maintain pond for drinking purpose;

Timely Maintenance of dug-well.

Punishment or penalty should be imposed to avoid adulteration with human consumptive water body.

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