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Prevalence of groundwater nitrate in Kolar district influenced by total rain fall and agricultural activity

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Abstract
The geographical area of Kolar district is about 4012 square kilometers, falls under eastern dry agro climatic zone of Karnataka, while population is over 20 lakhs. The primary occupation of 20 lakhs people of Kolar district is agro-chemically (fertilizers and pesticides) based agriculture. However, in fewer cases inadequate amount of compost manure is also adding to the soil for agriculture activity because compost manure producing biomass (livestock) of number drastically decreased due to water crisis and absence of natural vegetation as fodder. The water crisis is caused by inadequate rainfall and by overexploitation of groundwater or by combination of both. Since groundwater currently provides over 94% of all drinking water, it is crucial to control its quality. Groundwater is contaminated by the common anion nitrate (NO_3). This essay examines the analysis of chemical elements like nitrate in groundwater obtained from bore wells in various Kolar district communities. For the purpose of gathering and analyzing water samples, 50 different sampling sources were chosen. Nitrate concentration variations in water samples were noted. Selected water sample parameters that were analyzed were compared to IS 10500:2012 standards. The findings indicated that certain samples from sources had nitrate levels that were higher than the upper limit of the norm. The minimum standard level was also lower in some samples from various sources. Due to below-average rainfall, severely reduced cow breeding (livestock), and decreased agricultural operations, it may be because agro-chemicals (fertilizers and pesticides) and compost manure are used less frequently.

Keywords: Kolar District, rainfall, agriculture activity, nitrate concentration

Introduction

Nitrate, the oxidized form of dissolved nitrogen, plays a crucial role in supporting plant growth and is a fundamental component of the Earth's nitrogen cycle. This essential nutrient occurs naturally in soil as a result of microbial nitrogen transformations, atmospheric deposition, and the breakdown of organic matter. However, human activities especially intensive agriculture can disrupt this delicate balance, leading to nitrate-related issues that affect both environmental and human health.

In the realm of agriculture, nitrates are essential for optimizing crop yields. Farmers often employ nitrogen-based fertilizers to replenish soil nutrients, which can be depleted due to continuous cultivation. This practice increases agricultural productivity and helps to meet the food demands of a growing global population. However, excessive use of fertilizers, coupled with poor management practices can lead to the accumulation of nitrates in the soil and their subsequent leaching into groundwater and surface water bodies.

During monsoon rains used fertilizers might run off into water sources from there it infiltrates in to soil, thereby it causes groundwater contamination with nitrate (Anjali Verma *et al.*, 2014) [3]. Groundwater recharge is the main influential parameter for nitrate contamination in high-water table area (Michael *et al.*, 2015) [17]. The largest anthropocentric activity is intense farming which include excess applications of nitrogen fertilizers, manure application and growing of leguminous plants without employing of crop rotation pattern. Another potential source of nitrate to groundwater is leaching process from storage area of manure in farmland. Use of fertilizers, discharging of waste water from treatment plants and leakage of wastewater from cesspools increased levels in nitrate concentration in groundwater (Baalousha, 2008) [4]. The concentration of nitrate in the groundwater increased after fertilizer application to the agricultural crops (Nagiredii *et al.*, 2006) [18]. Increasing trend in nitrate concentrations in groundwater reflect aquifers overlaid with farmland (Vaclav *et al.*, 1989) [26].

The groundwater contamination with nitrate is mainly due to intensive organic farming alone (Dahan *et al.*, 2014) [7]. Sustainable agriculture reflected in lower levels of nitrate in groundwater (Alenka *et al.,* 2014) [2]. One common source of nitrate contamination is the use of nitrate fertilizers in irrigation. When water containing these fertilizers is applied to crops, the excess nitrates can infiltrate the soil and eventually make their way into nearby water sources. Additionally, improper management of septic systems and inadequately treated wastewater from sewage treatment plants can contribute to nitrate pollution in water bodies. Runoff from livestock operations such as dairies, can introduce high levels of nitrates into nearby streams and rivers (Maruthesh Reddy *et al.*, 2015) [16]. Groundwater nitrate contamination has been linked to intensive agricultural practices, inappropriate sewage treatment, and incorrect organic waste disposal (Sunitha, 2012) [22]. Nitrate contamination in groundwater is either caused by manmade activities like the use of fertilizers and septic tanks, or it is caused by natural processes like atmospheric fixation and lightning storms. Septic tanks, animal waste, human waste, and commercial fertilizers are the sources of nitrate to groundwater that are most frequently associated with pollution issues (Dennis Keeney *et al.*, 1986) [8]. The primary source of chemical fertilizer runoff and leaching from agricultural lands is the poisoning of groundwater with nitrate (Divya, 2012) [9]. Nitrate contamination in groundwater is mainly due to application of fertilizers in agricultural sector (Gunatilake, 2016) [11]. Agrochemical based agriculture is one of the severe major sources of nitrate pollution in groundwater (Jasna Nemecic Jurec *et al*., 2016) [12]. The main cause of groundwater nitrate contamination is due to percolation of nitrate contaminated runoff water in to groundwater during rainy season from cultivated field (Deepanjan *et al.*, 2000) [10]. The accelerated use of agricultural chemicals (synthetic nitrogen fertilizers and pesticides) is the main source of nitrate content in groundwater in the major agricultural areas of the world (George R Halberg., 1987) [13]. Nitrate is typically introduced to groundwater by the use of fertilizers in agricultural fields (Sajil Kumar, 2016) [23]. Large holes in the ground are a frequent method used by farmers in the Kolar District to store manure. While this method is practical and reasonably priced for the farmer in the near term, it causes excessive nitrate leaching. For organisms, including humans that depend on subsurface water, adverse biochemical effects may result when nitrate concentration reaches excessive levels. Locations with heavy fertilizer use, sewage systems, and animal waste disposal areas are the main sources of nitrate contamination in groundwater (Sajil Kumar *et al.*, 2014) [24]. Surface leaching from waste and wastewater disposal sites, animal waste disposal, industrial effluents, and N-based fertilizers are some of the sources of nitrate in groundwater (Chetan *et al.*, 2018) [5]. Intensive animal husbandry is one of the main causes of groundwater pollution with nitrate (Prafull Kumar Sahoo *et al*., 2016) [19]. Nitrogen fertilizers, sewage, animal waste, organic manure, the geology of subsurface soil layers, pit latrines, and other sources are examples of point and non-point sources of nitrate in groundwater (Surindra Suthar *et al.*, 2009) [25]. Occurrence of fluoride and nitrate in groundwater has become predominant challenge because of their ability environmental associated health impacts (Chethan Sharma *et al*., 2014) [6]. "Nitrogen compounds are biodegradable and an understanding of the physical chemical and biologic systems through which transient water is moving is important in analyzing chemical data (Jerold Behnke, 1975) [14]". Biochemistry of groundwater, compositions of rejuvenated groundwater and rate of rejuvenation is directly or indirectly effected by agricultural activities (John Karl Bohike, 2002) [15]. Agro-economy based rural areas are the causative factor for prevalence of nitrate in groundwater (Reddy AGS, *et al.*, 2009) [20]. As the proverb "solution for pollution is dilution" as such the rainwater harvesting is only the solution for mitigation of groundwater nitrate (Satish Kulkarni, 2013) [21].

Materials and Methods

Study area

Kolar District, spanning an area of 4,012 square kilometers, is home to a population of approximately 1.65 million residents. This District is divided into five talukas: Kolar, Bangarpet, Malur, Mulbagal, and Srinivaspur. Geographically, it stretches from north latitude 12°45'54" to east latitude 77°50'29".

The District encompasses 1798 villages, which are organized under the governance of 156-gram panchayats. The primary livelihood for the local populace revolves around agriculture, heavily reliant on bore well water for irrigation. Meteorologically, the region experiences a dry agro climate, falling under the classification of a semi-arid climate. This climate is characterized by tropical monsoons, featuring hot summers and relatively mild winters.

Kolar District's agrarian economy heavily depends on bore well water due to the absence of substantial surface water sources. The District's climatic conditions, with a semi-arid climate pattern, further emphasize the need for sustainable water resource management to support both agricultural activities and the drinking water needs of the local population.

Water samplings

In Kolar District, groundwater samples were systematically gathered from a total of 50 distinct bore wells situated across various villages. These samples were collected during both the "pre-monsoon and post-monsoon seasons of the years 2014 and 2015", ensuring a comprehensive understanding of the potential variations in groundwater quality over time.

Analysis of samples

In the assessment of groundwater quality within Kolar District, a comprehensive analysis was conducted on all collected samples. Beyond nitrate levels, several crucial physico-chemical parameters were measured to provide a holistic understanding of the water's composition. These parameters included pH, chloride, fluoride, and total hardness, which play vital roles in determining the overall quality and suitability of groundwater for various uses.

Methodology

Synthetic fertilizer waste contains significant amounts of nitrates, which the end products are resulting from the aerobic stabilization of organic nitrogen compounds. In the analysis of these nitrates, the phenol-di-sulphonic acid method is employed, which involves a series of chemical reactions leading to the formation of a yellow-colored solution.

In order to begin the analysis, a well-mixed sample of the synthetic fertilizer waste is taken and evaporated in a glass dish, utilizing a water bath for controlled evaporation. Following this, 2 ml of phenol-di-sulphonic acid is added to the residue to ensure complete dissolution. Subsequently, a

50% sodium hydroxide (NaOH) solution is introduced until the red litmus indicator changes to blue. The resulting mixture is then filtered and brought up to a total volume of 50 ml in a Nessler's tube, a specialized tube used for colorimetric measurements.

In order to establish a baseline, a blank sample is prepared by treating 50 ml of distilled water using the same procedure as the sample. This blank serves as a reference point for comparison during the subsequent measurement.

The actual measurement is carried out at a specific wavelength, in this case, 450 nm, utilizing a spectrophotometer. This device allows precise quantification of the intensity of the yellow coloration in the samples, providing valuable data on the concentration of nitrates present in the synthetic fertilizer waste.

By following this detailed analytical procedure, the phenol-di-sulphonic acid method offers a reliable means of assessing nitrate levels in synthetic fertilizer waste. This information is essential for understanding the potential environmental impact of these wastes and for implementing proper waste management strategies to mitigate any adverse effects on ecosystems and human health.

Results and Discussion

The rainfall in the district is very erratic and maximum fluctuation recorded in last few decades. The rainfall for the year 2014 and 2015 was below the normal level. Though it is hit by drought, water scarcity and in the absence of surface water bodies such as dams or canals, bore wells are the sole source of water for drinking as well as intensifying agriculture.

Monthly wise rainfall (In mm) variation in Kolar District from 01-01-2014 to 31-12-2015 are given Table 1. All types of life require water, which is also utilized in a variety of ways. However, the availability of water is currently declining quickly. Limited water storage capacity, limited infiltration, greater yearly changes in precipitation (due to unpredictable distribution of monsoon rains), and high evaporation demand are the main causes of water scarcity. The majority of the water is sourced underground. These sources rely on the recharging of groundwater caused by rainwater seeping into the earth. Rainfall in India only occurs during the monsoon season. Due to the brief duration of heavy rain, the majority of the rain that falls on the surface tends to quickly flow away (runoff), leaving very little for groundwater recharging (Satish, 2013) [21]. Rainfall is determined by geography and weather system (pattern of large air movements). The distribution of rainfall over the year is an important limiting factor for organisms.

The total monthly rainfall of Kolar District varied from 0.0 to 491.8mm. It was nil during February 2014-2015. It was negligible during April-2014 and December-2014. During May-2014 and 2015 the rainfall had moderately increased, then sturdily increased in June 2014 reaching the maximum rainfall such as 243.5 mm. Later suddenly decreased in August 2014. But the maximum rainfall like 248.0, 270.0, 329.6 and 491.8 mm were recorded in September, October and November-2014 and 2015 (Table 1).

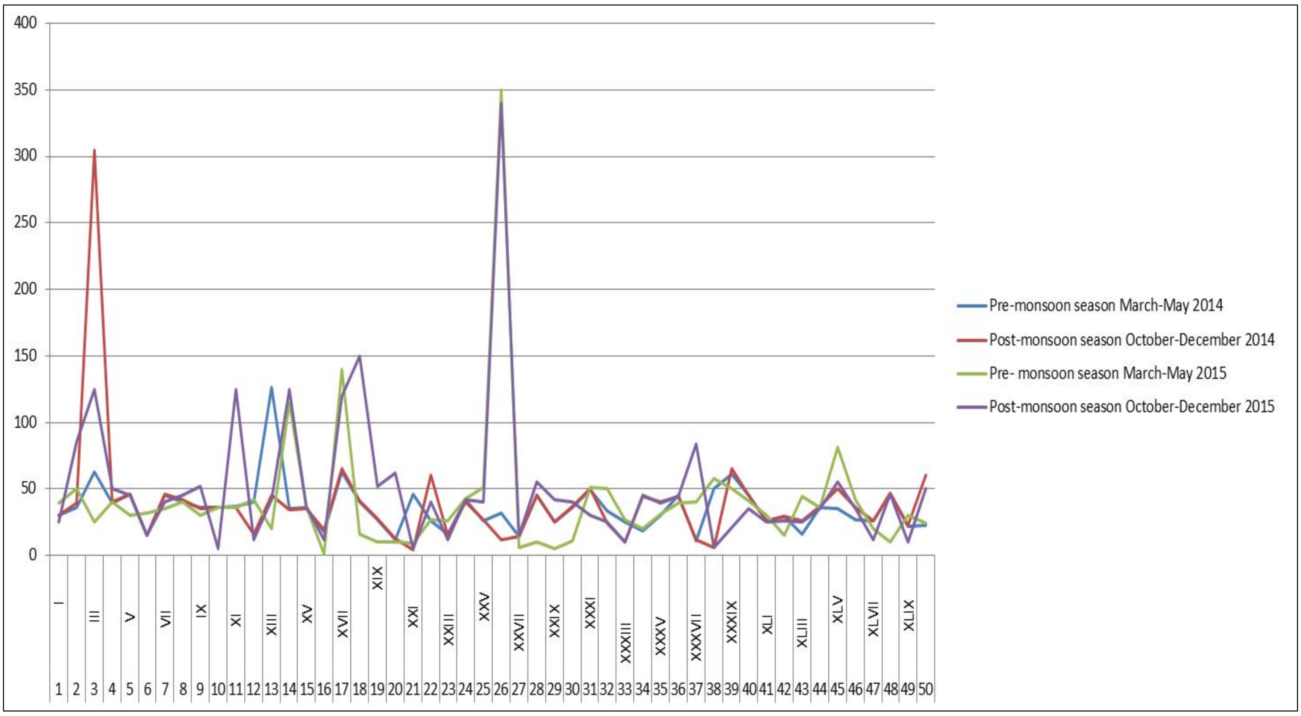
Rainfall during the pre-monsoon season of 2014 one Taluk had normal rainfall and 4 Talukas had deficit rainfall. During south-west monsoon, two Talukas received normal rainfall and 3 Talukas received deficit rainfall. During North-East monsoon, 2 Talukas had excess rainfall and one Taluk received normal, deficit and scanty rainfall. The classification of overall annual status indicates that 2 Talukas had normal rainfall and 3 Talukas received deficit rainfall. The district average annual rainfall was 624 mm. However, compared to the year 2014, in the year 2015 all the Talukas of the Kolar District received maximum and sufficient rainfall (1252.9 mm at Bangarpet Taluk and 1294 mm at Malur Taluk). With an increase in the inflow, all villages of Kolar District were blessed with plenty of water. Revival of these surface water bodies causes improvement in the water levels of borewells and pronounces the proverb solution for pollution is dilution.

"The concentration of nitrate varies between sources and seasons. Nitrate concentration levels ranged from a minimum of 11.1 mg/L to a maximum of 126.0 mg/L throughout the warm months of March to May in 2014. In contrast, the same season in 2015 showed a minimum of 5.0 mg/L and a maximum of 350.0 mg/L. Similar to this, the readings for nitrate concentration during the post-monsoon season (October to December) of 2014 showed minimum values of 40.0 mg/L and maximum values of 65.0 mg/L. In contrast, the same season in 2015 showed a minimum of 5.0 mg/L and a maximum of 340.0 mg/L. Pre-monsoon season in 2014 showed 35.6 mg/L when compared to same season in 2015, which showed 41.2 mg/L when compared to overall average values. The same post-monsoon season in 2014 showed 33.5 mg/L, but the same season in 2015 showed as 50.3 mg/L".

Table 1: "Taluk wise and monthly wise rainfall variation in Kolar District from 01-01-2014 to 31-12-2015"

Months	Talukas and year									
	Bangarpet		Kolar		Malur		Mulbagal		Srinivaspur	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
January	0.0	18.4	0.0	4.2	0.0	7.4	0.0	0.0	0.0	3.0
February	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
March	3.6	59.6	0.0	46.6	27.4	75.0	53.7	4.2	5.0	46.5
April	0.0	124	0.0	75.6	3.2	128.2	0.0	30.9	0.0	90.5
May	80.0	68.6	123.1	111.4	82.8	210.4	69.2	52.2	75.0	149.5
June	85.8	121.0	77.6	45.0	90.4	58.8	243.5	38.4	62.5	66.0
July	54.5	21.2	63.6	58.4	42.2	45.0	30.2	25.6	28.0	32.0
August	26.8	119.5	79.0	101.4	15.9	101.2	56.4	127.3	66.0	91.1
September	41.6	151.0	153.0	145.6	115.0	248.0	112.0	221.3	97.5	152.0
October	239.7	61.4	183.4	16.0	270.0	170.0	47.0	84.0	144.0	100.1
November	40.2	491.8	25.4	329.6	30.0	250.8	28.8	444.3	28.0	429.5
December	4.2	16.4	3.6	13.0	16.2	15.4	0.0	24.0	6.0	3.0

"Table 2, Showing seasonal changes in the concentration of nitrate from different sources at study area Kolar District for the period pre-monsoon season and post-monsoon season 2014 and 2015



Note: "In graph X-axis showing source number and Y-axis showing concentration level of nitrate in mg/L".

Fig 1: Showing seasonal changes in the concentration of nitrate from different sources at study area Kolar District for the period pre-monsoon season and post-monsoon season 2014 and 2015

Table 2: Showing Seasonal changes in the concentration of nitrate from the different sources at study area Kolar District for the period of two years 2014 and 2015 in two different seasons pre-monsoon and post-monsoon

SL. No.	SL No. of the Sources	Pre-monsoon season March-May 2014	Post-monsoon season October-December 2014	Pre-monsoon season March-May 2015	Post-monsoon season October-December 2015	Average
1	I	30.2	30.3	39	25	31.125
2	II	35.69	39.5	50	85	52.5475
3	III	63.1	305	25	125	129.525
4	IV	39.4	40	40	50	42.35
5	V	45.69	46	30	45	41.6725
6	VI	15.45	15.47	32	15	19.48
7	VII	45	46	35	40	41.5
8	VIII	40.1	42.1	40	45	41.8
9	IX	35.6	35	30	52	38.15
10	X	35.69	35.7	36	5	28.0975
11	XI	36.9	35.8	36	125	58.425
12	XII	40.2	16	41.6	12	27.45
13	XIII	126	45	20	42	58.25
14	XIV	35	34	115	125	77.25
15	XV	35.62	35	36.6	37	36.055
16	XVI	18	19	0.51	12	12.3775
17	XVII	63	65	140	120	97
18	XVIII	40.1	41.1	16	150	61.8
19	XIX	26.53	27.31	10	52	28.96
20	XX	12.05	12.5	10	62	24.1375
21	XXI	45.8	4	9	5	15.95
22	XXII	25.6	60	27	40	38.15
23	XXIII	15.5	15	26.1	12	17.15
24	XXIV	42.2	40	43	42	41.8
25	XXV	25.6	26.6	51	40	35.8
26	XXVI	32	12	350	340	183.5
27	XXVII	14.45	14.45	6	15	12.475
28	XXVIII	45	45	10	55	38.75
29	XXIX	25.32	25.35	5	42	24.4175
30	XXX	36	37	11	40	31
31	XXXI	49.23	50	51	30	45.0575
32	XXXII	33.4	24	50.1	25	33.125
33	XXXIII	25.4	10	26.5	10	17.975
34	XXXIV	18.3	44	20	45	31.825

35	XXXV	29.9	40	31	39.1	35
36	XXXVI	44.8	44.45	39	44	43.0625
37	XXXVII	11.1	11.45	40	84	36.6375
38	XXXVIII	50	6	58	6	30
39	XXXIX	61	65	50	21	49.25
40	XL	45	45.1	41	35	41.525
41	XLI	25.7	26	30.1	25.21	26.7525
42	XLII	29	29.31	15	26.2	24.8775
43	XLIII	16	26	44	25	27.75
44	XLIV	36	36.7	36	35	35.925
45	XLV	35.1	50	81	55	55.275
46	XLVI	27.1	36	42	35	35.025
47	XLVII	26	26.27	20	12	21.0675
48	XLVIII	46	46.5	10	46	37.125
49	XLIX	22	22.25	30	10	21.0625
50	L	23	60	24	50	39.25

Source: Author”

Conclusion

Lesser concentration of nitrate is due to erratic distribution of rainfall during monsoon season and rain fall was lesser than normal level, insufficient replenishment of groundwater, lesser agricultural activity with minimum usage of agrochemicals (fertilizers and pesticides) and drastically deceasing of compost manure producing biomass (livestock) of number. Higher concentration is due intensive use of agrochemical with indiscriminate use of groundwater and excessive leaching of nitrates. Finally, It is suggest that the water should be properly treated before consumption and minimizing discharge from irrigated agricultural lands.

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