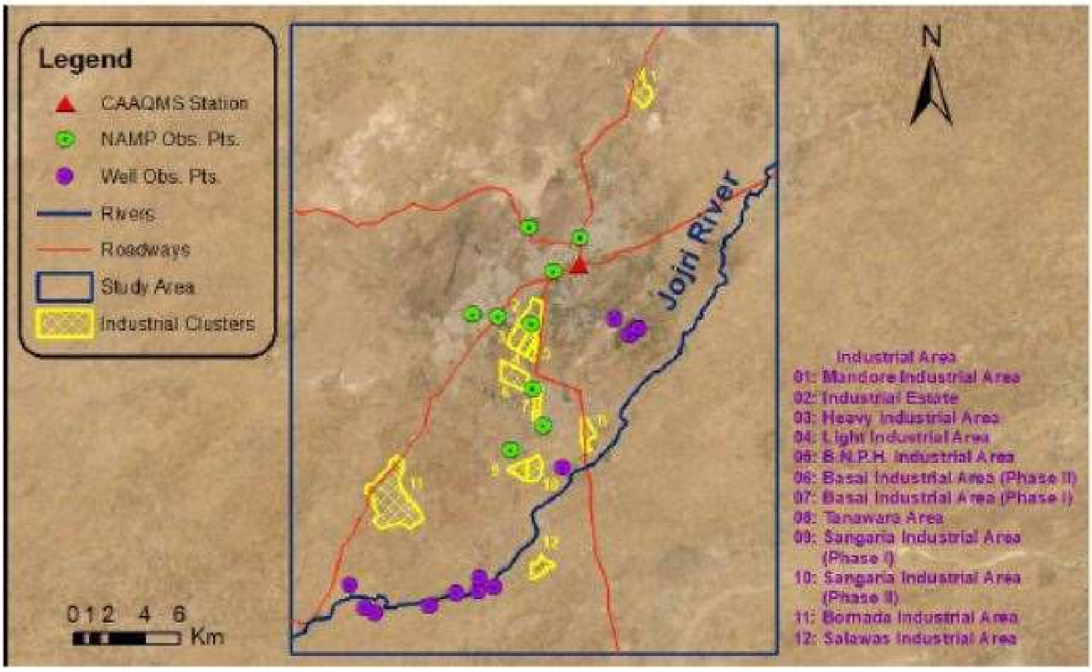
Comprehensive Environmental Pollution Abatement Action Plan for Critically Polluted Industrial Cluster– JODHPUR



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Report and Investigators detail

Project Title: Comprehensive Environmental Pollution Abatement Action Plan for Critically Polluted Industrial Cluster of Jodhpur

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Executive Summary

RPCB has entrusted MNIT Jaipur to prepare revised environmental action plan for critically polluted industrial cluster of Jodhpur.

To assess the pollution problem presently in Jodhpur, CEPI scores were calculated using the original and modified methodology of CEPI. While compiling data for CEPI calculations, it was observed that data for heavy metals and pesticides were not available except for Jojari River. As the methodology of the CEPI calculation depends on the exceedance factor, the concentration of the pollutants is a major factor. Hence the pollutants selected and their order are very important in calculating CEPI score. THE CEPI scores for different components i.e. land, water and air in original methodology and ground water, surface water and air in modified methodology). Moreover, the comparison should be made only between similar types of methodologies e.g. scores from original CEPI methodology should be compared with the scores from revised CEPI methodology, as the two approaches are widely different. It was also learned that while collecting the data, the data for carcinogens like heavy metals and pesticides should also be collected by the government agencies to assess any long term health implications of pollution.

Finally a revised action plan has been suggested for the industrial cluster of Jodhpur, taking into account the specific industry types of cluster and other conditions.

1. INTRODUCTION

Comprehensive Environmental Pollution Index CEPI is an environmental indicator to evaluate the quality of environment at a given location. It links source, pathway and receptor as in conceptual site model (USACE, 2012). An increase in value of CEPI score indicates increase in adverse effects on environment. Furthermore, it also gives an indication of harmful effects on population, flora, fauna and archaeologically important buildings.Recently the methodology for estimation of CEPI score has been modified to make it more user-friendly.

Jodhur and Pali industrial clusters have been found to be critically polluted based on estimation of CEPI score in 2009, 2011, 2013 and 2018 (Fig. 1, (CPCB, n.d.)).

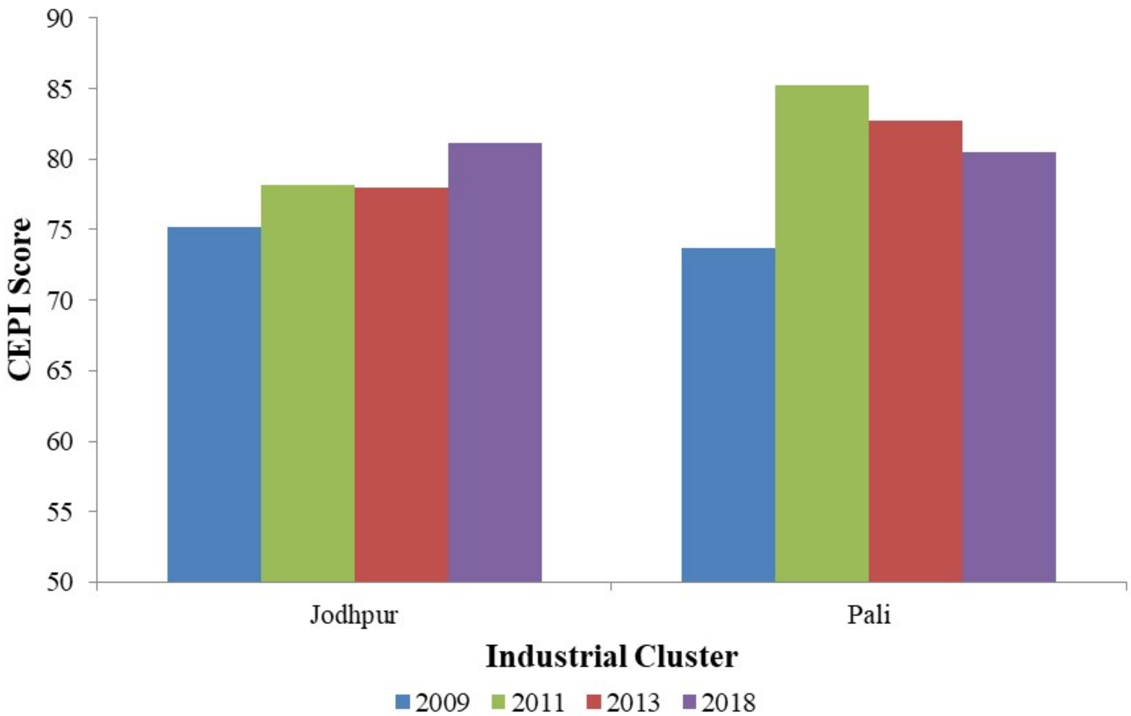

Figure 1: CEPI scores for industrial clusters of Jodhpur and Pali

As per directions from National Green Tribunal (NGT), Rajasthan State Pollution Control Board (RPCB) needs to take action to improve the environmental conditions in Jodhpur and Pali. RPCB has entrusted MNIT to prepare the revised action plan for the same.

2. JODHPUR INDUSTRIAL CLUSTER

Jodhpur, an industrial and tourist city in Rajasthan, is the administrative headquarters of Jodhpur District.

2.1 Area and Demography

Jodhpur district extends between 25°51'08" & 27°37'09" North latitude and 71° 48' 09" & 73° 52' 06" East longitude covering a geographical area of 22,850 sq km. The headquarters of Jodhpur district is the city of Jodhpur, the second largest city in Rajasthan.

Population of the district is 36.87 lakhs as per 2011 census while Jodhpur Nagar Nigam and out growths have a total area of10.6 lakhs. The district falls under western arid zone of the Rajasthan State and covers 11.60% of total area of arid zone of the state. The district is divided into 5 sub-divisions namely Jodhpur, Shergarh, Pipar City, Osian&Phalodi and comprises of 07 tehsils and 09 blocks. Total number of villages in the district is 1157 as per 2001 census. The district is known for its Guar gum industries and mineral wealth. Fig. 2 shows the Jodhpur city study area considered in this project and also digital elevation model of the study area. North-west region of the Jodhpur city study area has higher elevation ranging between 235 to 352 m above mean sea level (mamsl) and rest of the area has lower elevations ranging between about 125 to 230 mamsl. Refer Fig. 3 for Jodhpur Industrial Cluster Location Map. There are 10 industrial clusters mostly in south part of Jodhpur city except cluster no. 1, Madore Industrial area, which lies in the north part of Jodhpur city.

2.2 Topography

Major physiographic units of Jodhpur are Sand Dunes, Alluvial plains, Ridges and Hillocks which lies scattered in the area, while major drainage is offered by Luni River and Mithari River. Jodhpur district forms part of Great Thar Desert of Rajasthan. This district is situated at the height between 125-350 meters above sea level.

The Eastern part of the district area exhibits gentle undulating topography interrupted by small ridges of hard rocks. The area between Bilara and Jodhpur in the eastern part of the district is covered by alluvium deposited due to fluvial action of Luni river system. The general elevation of plains varies from 300 m above mean sea level in north to 150m above mean sea level in South. Regional slope is from North-East towards South-West direction. Orientation of alluvial plain area follows the Luni River and its tributaries. Sand dunes occupy a major part of the district north of Vindhyan escarpment in northern and northwestern part of the district(PDCORE and IL&FS 2013). This slope results in all the wastewater originating from the domestic premises as well as the industrial clusters to flow southwards through Jojari river creating some environmental problems in the downstream stretches.

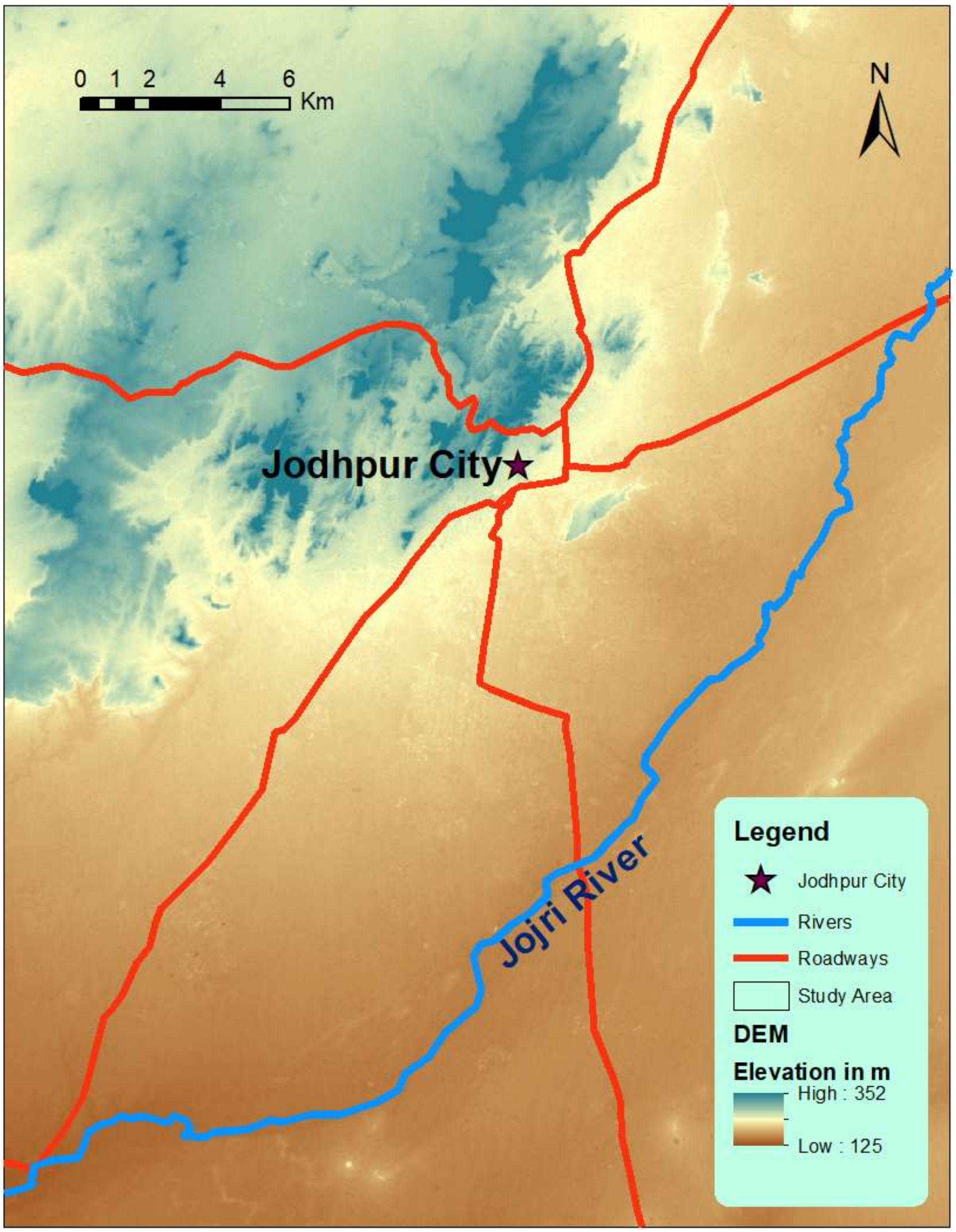

Figure 2: Digital elevation model for Jodhpur

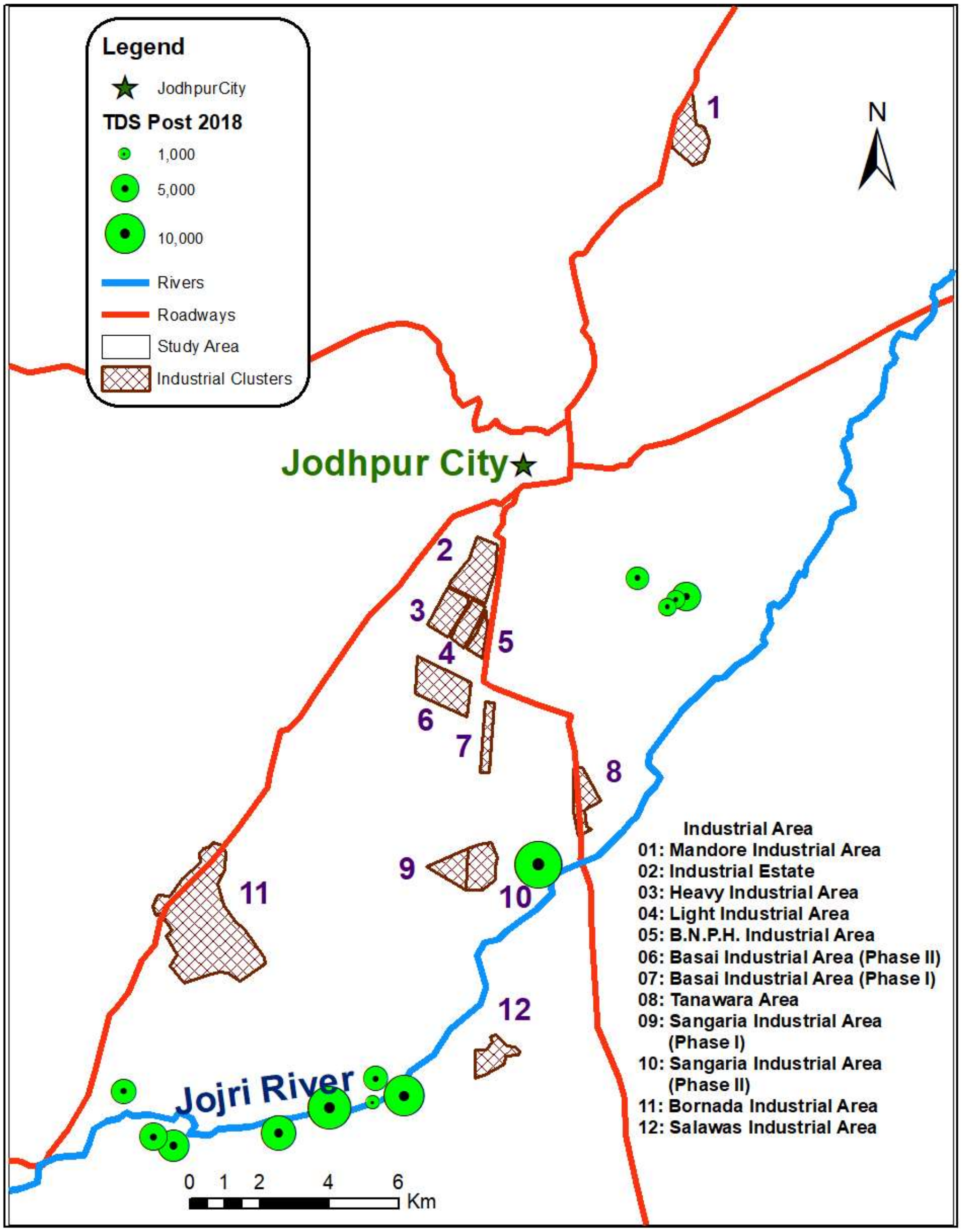

Figure 3: Jodhpur Industrial Cluster Location Map (map also shows the groundwater quality in terms of TDS)

2.3 Climate

Jodhpur exhibits similar climatic conditions as in the dessert namely; arid to semi arid type of climate with extreme of heat in summer and cold in winter. The temperature varies from 49 degree in summer to 1 degree in winter. Both day and night temperature increases gradually and reaches their maximum values in May and June respectively.

The average rainfall in this region is about 300mm. Atmosphere is generally dry except during the monsoon period. The humidity is highest in August with mean daily relative humidity of 81%. The annual maximum potential evapo-transpiration in the district is quite high. It is highest (264.7 mm) in the month of May and lowest (76.5 mm) in the month of December(PDCORE and IL&FS 2013).

2.4 Geology and soils

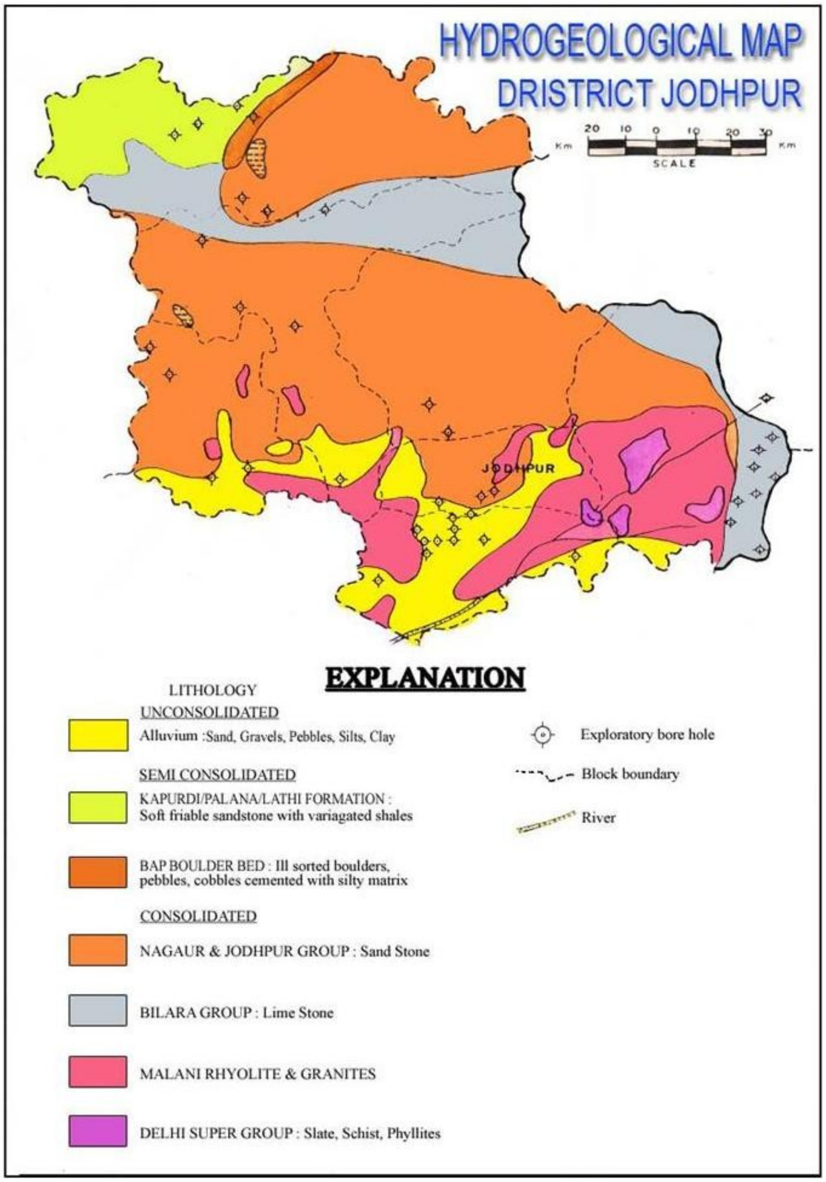

Figure 4: Hydrogeological Map of Jodhpur District (PDCORE and IL&FS 2013)

The geological set-up of the district is represented by various igneous, metamorphic and sedimentary rocks. Predominant geologic formations are Quaternary

Aeolian sand, Alluvium, Bap Boulder Bed, Nagaur Sandstone, Bilara Limestone and Jodhpur Sandstone of Marwar Super Group, Malani Igneous Suite, Eranpura granite & rocks of Delhi Super Group. Delhi Super Group litho units are very limited and in the form of isolated pockets. Erinpura granites and Malani igneous rocks cover large area in the southern part of the district. Marwar Super Group of rocks occupies maximum geographical area of the district lying in the central, western, and eastern parts of the district. The rock units of various formations belonging to Cenozoic epoch/era represented in very small area, lies in the north-western parts of the district. In the entire district, the hard rocks are overlain by thin blanket of alluvium and windblown sand(PDCORE and IL&FS 2013).

Major water bearing formations here are Quaternary alluvium, Nagaur Sandstone, Bilara Limestone and Jodhpur Sand -stone, Rhyolite, Granite, Schist and Phyllite. Please refer Fig. 4for the details.The major and important minerals of the district are sand stones and lime stones. Fawn and Red colored sandstone of the district is very popular and found in abundance. Besides this, building stones, stone slabs and flagstones are mined in the district on regular basis. Minerals like quartz and clays of various colours and dolomite are also available in the district.

Soil of the district is classified mainly as sandy and loamy. The types of soils found in the area are: Red soils, Desert soils, Lithosol and Regosols of hills.

2.5 Vegetation

Bajra (pearl millet) is the major crop during Kharif season in Jodhpur. In Rabi season wheat, pulses and a variety of masala like jeera, dhania and red chilly are also grown. It is one of the major production centers for guar.On account of arid climate, only negligible percentage of the total reporting area for the landuse in the district is covered under forests. Despite its arid climate, Jodhpur is blessed with a variety of flora and fauna. Due to sandy soil only scrub and thorny bushes of vegetation are found in the forest areas of the district. The main species of trees are Kumat, Kair, Khejri, Babul, Bir, Jal khara, Pilu, etc. Fruit bearing trees are pomegranates and guavas. The fauna of the district include Jackal, Jungle Cat, Indian Fox, Black Buck, Chinkara, common Hare, etc. The birds commonly found are Baya, Koyal, Parrot, Vulture, Jungle Crow, bulbul, House Sparrow, Kite, Sand Grouse, Common Quail, grey Partridge, little Egrit, etc. A survey conducted by district administration with the help of forest officials shows 162 flora and 144 fauna at Machia Safari situated only 10 kms from Jodhpur(PDCORE and IL&FS 2013).

2.6 Industrial Development

Jodhpur is the third most industrialized district in Rajasthan. Jodhpur district accounts for 6% of the net domestic product from the Mining and Manufacturing Sector of the state. In the recent years, Jodhpur has increasingly become the important industrial centre. About 1968 acres land is under industrial development, which is 12.06% of total developed area and is likely to be 5135 acre in 2023 under Master Plan-II (2001- 2023). Main industries of Jodhpur are textiles, handicrafts, steel re-rolling and patapatti, guar gum, chemicals and minerals, stone cutting and processing and food processing units(PDCORE and IL&FS 2013).

Jodhpur industrialization started with the announcement by then Jodhpur government to set up two industrial areas here namely a light industrial area and a heavy industrial area. After this, the Industries Department of the State Government setup 529 acre Industrial estate at BhagatkiKothi, behind New Power House. Additionally New Jodhpur & Electronics Complex was established by RIICO with 107 plots which are completely developed. Further, many general and special industrial areas are being planned and developed by RIICO.

Jodhpur is located in the western part of the Rajasthan and has suffered scarcity of water prior to supply of water from Rajiv Gandhi Nahar Project (RGNP) and therefore there is hardly any industry which may be classified as water incentive industry i.e., consumption more than 1,000 KLD(PDCORE and IL&FS 2013).

2.6.1 Location of Industrial Areas

Most of the industrial areas in the cluster are located to the South and South West of Jodhpur city; while Mandore is located to the north of the city. Light and Heavy Industrial Area, Industrial Estate, BNPH, Basni (Phase I & II), Tanawada, Salawas, Sangaria and Bornada are proximal to each other, mostly sandwiched between NH-112 and NH-65. Mandore Industrial Area is approached by NH-65 and SH–61.

2.6.2 Industry Classification and distribution in Jodhpur

The industries in Jodhpur city are mainly located in Industrial Areas developed mainly by RIICO. Mandore Industrial Area, developed by RIICO on the Jodhpur-Nagaur road at about 16kms from the city is an established industrial area to the north of the town. A stone park is also developed by the RIICO in which units related to the cutting of stone slabs (Sand Stone) would be established. To the west side of the city at about 20kms on Barmer Road, there exists Boranada Industrial Area developed by RIICO.

Following industrial areas exist to south of the city within Municipal Limits:

- Light Industrial Area
- Industrial Estate
- Behind New Power House.
- Heavy Industrial Area
- Marudhar Industrial Area Phase- I
- Marudhar Industrial Area Phase-II
- Sangaria Industrial Area.
- Stone

The textile industries of Jodhpur are mostly engaged in screen-printing process. The finished products in 60% of industries are printed fabric where as 40% are dyed and bleached fabrics.

The industrial activities in the Basani industrial area is dominated by small scale Textile Processing units (157 units), small scale Stainless Steel (SS) rerolling industries (91 units), handicraft units (31 units), Guargum processing units (21 units), small scale engineering units (8 units) and other units (105 units). Besides, all the water polluting textile processing units and S S rerolling units are connected with CETP for treatment of their effluent. All the Guargum units have established adequate measures for control of air pollution. The industrial activities in the Heavy Industrial Area and Industrial Area behind New Power House is dominated by small scale textile processing units (76 units), small scale SS rerolling industries (19 units), handicraft units (8 units), small scale engineering units (3 units) and other units (9 units) (PDCORE and IL&FS 2013).

2.6.3 Land uses in impact zones

Major land uses in the impact zones of Jodhpur Industrial Cluster are presented here.

Table 1: Land Use Area for Jodhpur Industrial Cluster (PDCORE and IL&FS 2013)

Industrial Areas	Landuse Class	Area (Sqkm)
Basni Industrial Area (Phase-I&II)	Vegetation Low Density	1.90
	Water Body	0.02
	Urban Low Density	3.66
	Industrial Low Density	0.10
	Industrial High Density	3.00
	Airport	0.13
Bornada Industrial Area	Vegetation Low Density	0.21
	Water Body	0.00
	Settlement Village	0.02
	Urban Low Density	0.04
	Industrial High Density	1.34
Industrial Estate, Heavy Industrial Area, Light Industrial Area, B.N.P.H Industrial Area	Water Body	0.03
	Vegetation Low Density	3.95
	Urban Low Density	2.84
	Urban Medium Density	4.27
	Urban High Density	1.32
	Industrial Low Density	0.02
	Industrial High Density	1.06
Mandore Industrial Area	Water Body	0.02
	Vegetation Low Density	0.71
	Settlement Village	0.57
	Urban Low Density	0.22
	Industrial Low Density	0.46
Salawas Industrial Area	Water Body	0.12
	Vegetation Low Density	0.08
	Settlement Village	0.23
	Industrial Low Density	0.15
Sangaria Industrial Area (Phase-I&II)	Urban Low Density	1.51
	Water Body	0.13
	Vegetation Low Density	0.47
	Settlement Village	0.14
	Industrial High Density	0.05
	Industrial Low Density	0.03
Tanawara Area	Water Body	0.23
	Vegetation Low Density	1.35
	Settlement Village	0.26
	Urban Low Density	2.17
	Industrial Low Density	0.18
	Industrial High Density	0.12

2.7 Eco-sensitive zones

2.7.1 Ecological Parks, Sanctuaries, Flora and Fauna

A Forest Nursery is seen in the impact zone of Mandore Industrial area. Zoological garden in the old city area falls in the impact zone of Heavy / light industrial areas.

2.7.2 Historical Monuments

Heavy and Light industrial areas almost about the old city. Hence many monuments and historically important places and buildings of heritage importance fall within the impact zone of this area.

3. ESTIMATION OF CEPI SCORE

For CEPI calculation, data regarding quality of air, surface water, groundwater and soil need to be collected. Moreover, information has to be collected for number and type of industries in the area, patients visiting hospitals in the area with ailments owing to air and/or water pollution, ecological features in the area and places of historical importance. These data were provided to MNIT by RPCB offices in Jodhpur and Pali.

3.1 Air Environment

3.1.1 Wind rose for the area and ambient air quality monitoring station

Wind rose for the area is presented in Figure 5, which has been generated from the available annual average wind data for 2017. It shows that the prominent wind direction is from SW and SSW with mostly low to moderate wind velocities of up to 20 KMPH and hence the dominant transport of air pollutants released from the industrial clusters would occur in the areas of the city situated in the NE-NNE directions from them.

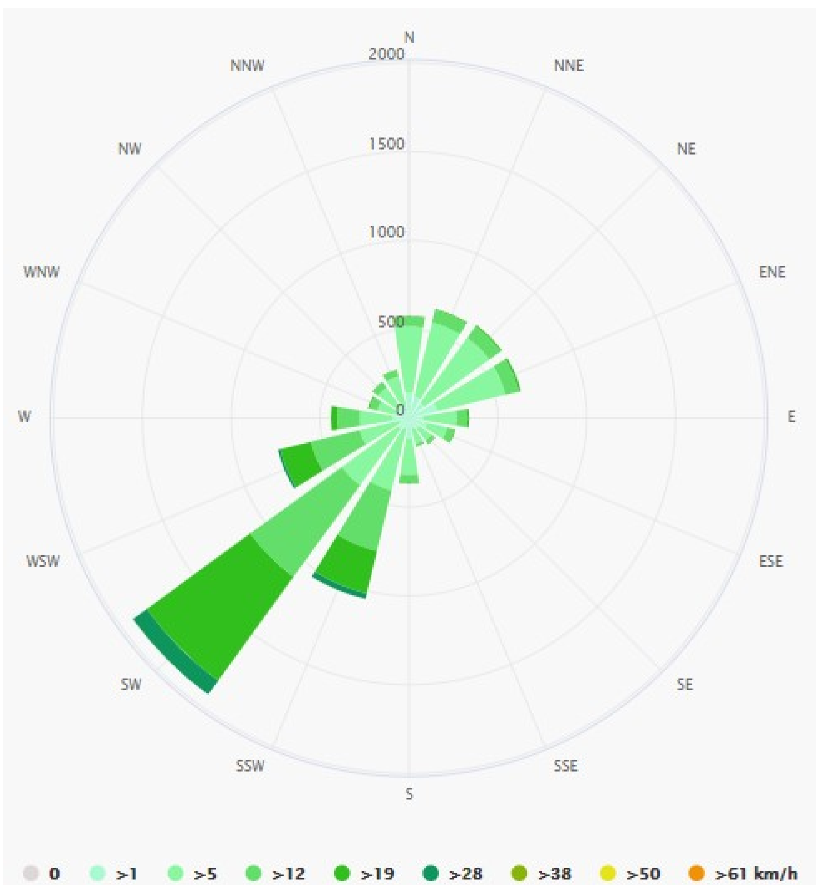

Figure 5: Wind rose for Jodhpur

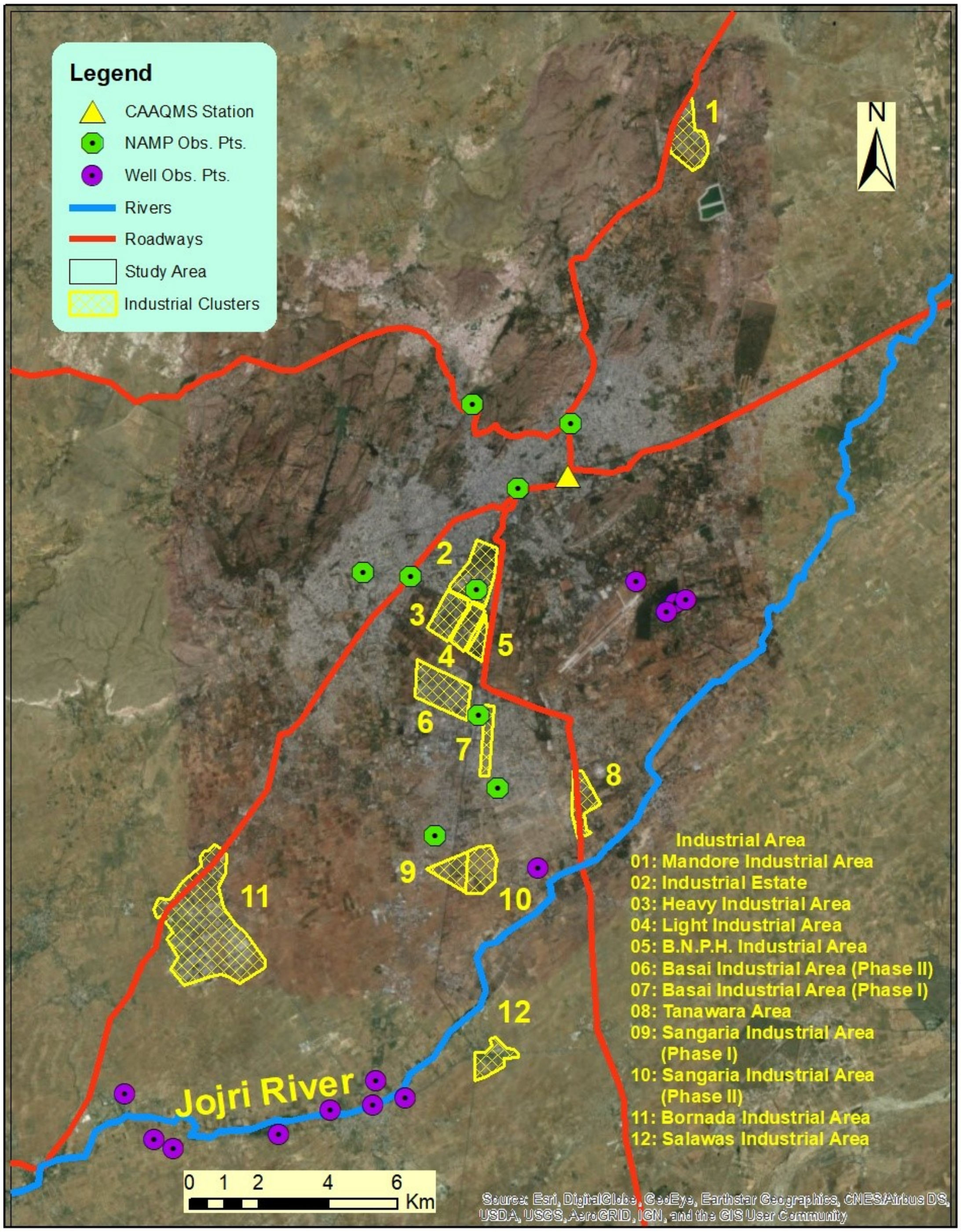

Figure 6: Location of air quality monitoring stations in Jodhpur industrial cluster under NAMP and CAAQMS

There is one continuous ambient air quality monitoring station (CAAQMS) located in the area and it is suitably located in the NE direction (Figure 6) to capture any expected hot spots for air pollution due to industrial emissions. There are nine other air quality monitoring stations installed under national air quality monitoring programme (NAMP).

3.1.2 Trends for air quality

Figs. 7-12 depict the air quality trends in Jodhpur cluster area. Fig. 7 shows the annual trend of $PM_{2.5}$, figs. 8-12 show the seasonal trends of the pollutants including O_3, NH_3, NO, NO_2 and $PM_{2.5}$. The pollutants are increasing in general on a temporal scale. However, one striking feature is the dip in the concentrations of Ammonia in year 2018, which is predominantly coming from the textile industries during the processing of cloth. The observed dip may be due to the closure of industries in the region as a result of order from NGT in year 2018 for a long duration. It is further strengthened by the fact that a marginal dip in NO values was also obtained, which may have some contribution as a secondary pollutant from ammonia in air. Since the major contributor to NO_x would be vehicular pollution, the overall trend in NO_2 was similar to that of other parameters. This also signifies that there is little impact of industrial pollution on other parameters of air quality monitored as these are mainly water intensive units with only boilers being used for hot water production and hence ammonia may be taken as a primary pollutant representing industrial contribution. Further, NO_2 and $PM_{2.5}$ may be taken as secondary pollutants for CEPI calculations.

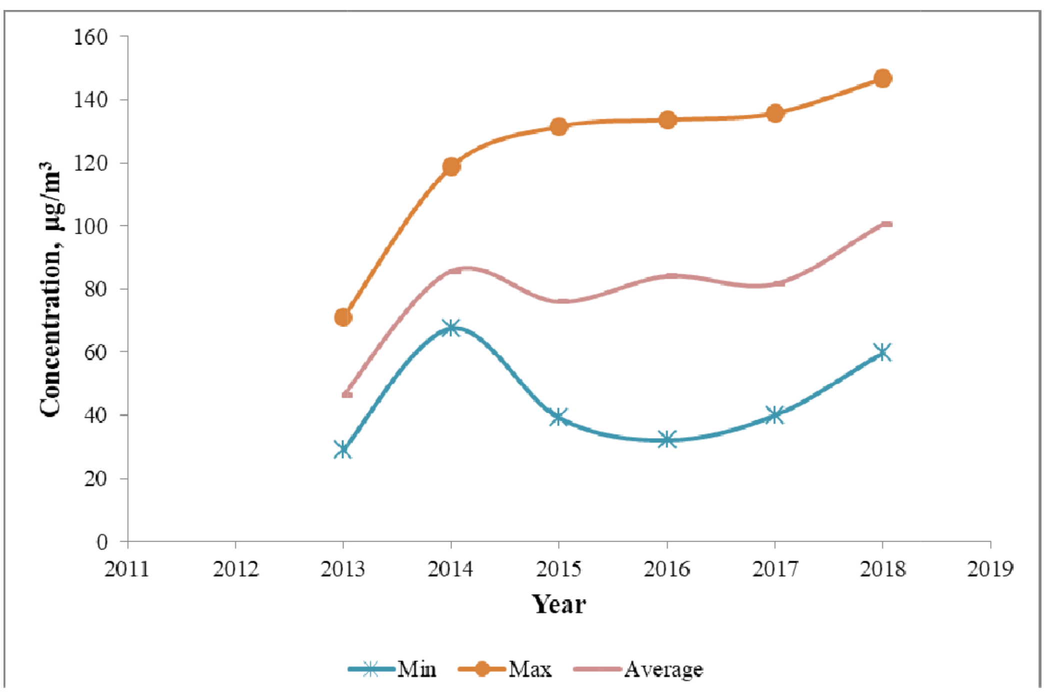

Figure 7: Annual Trend for average concentration of $PM_{2.5}$ in Jodhpur industrial cluster

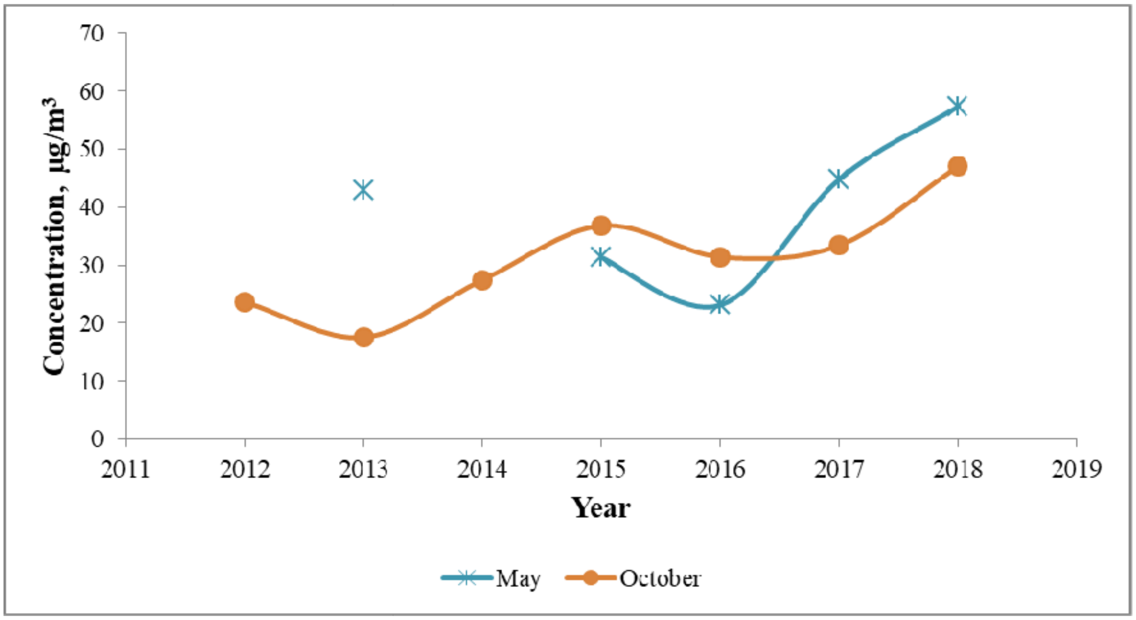

Figure 8: Seasonal trend for O_3 in Jodhpur industrial cluster

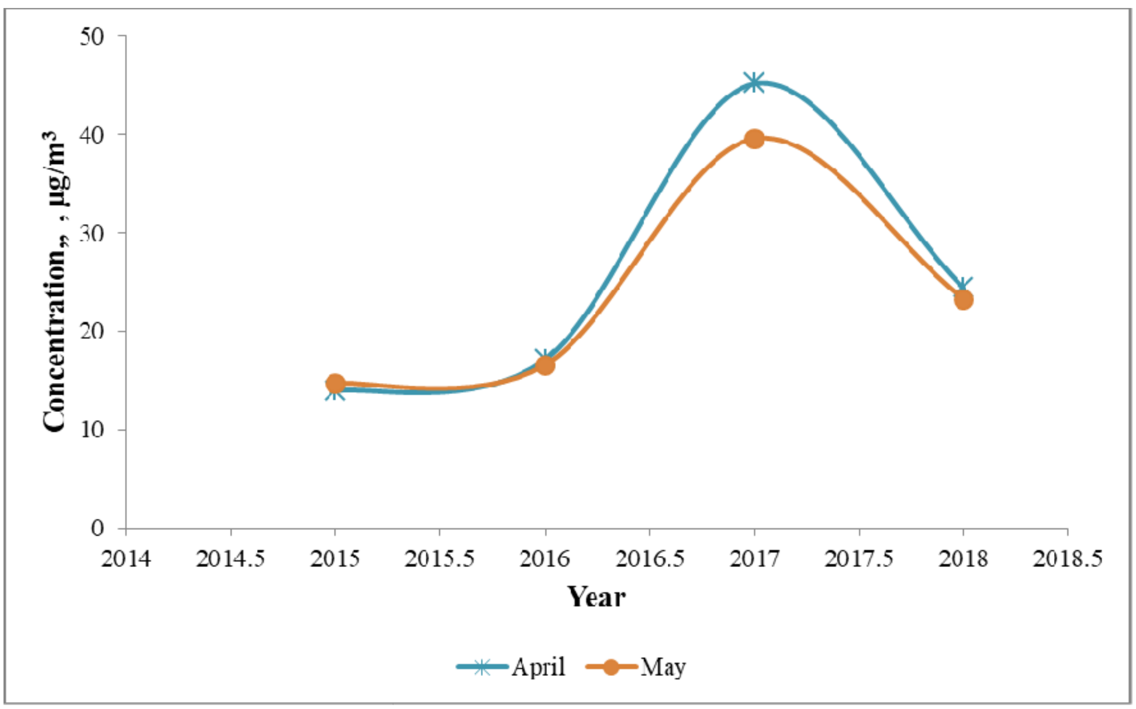

Figure 9: Seasonal trend for NH_3 in Jodhpur industrial cluster

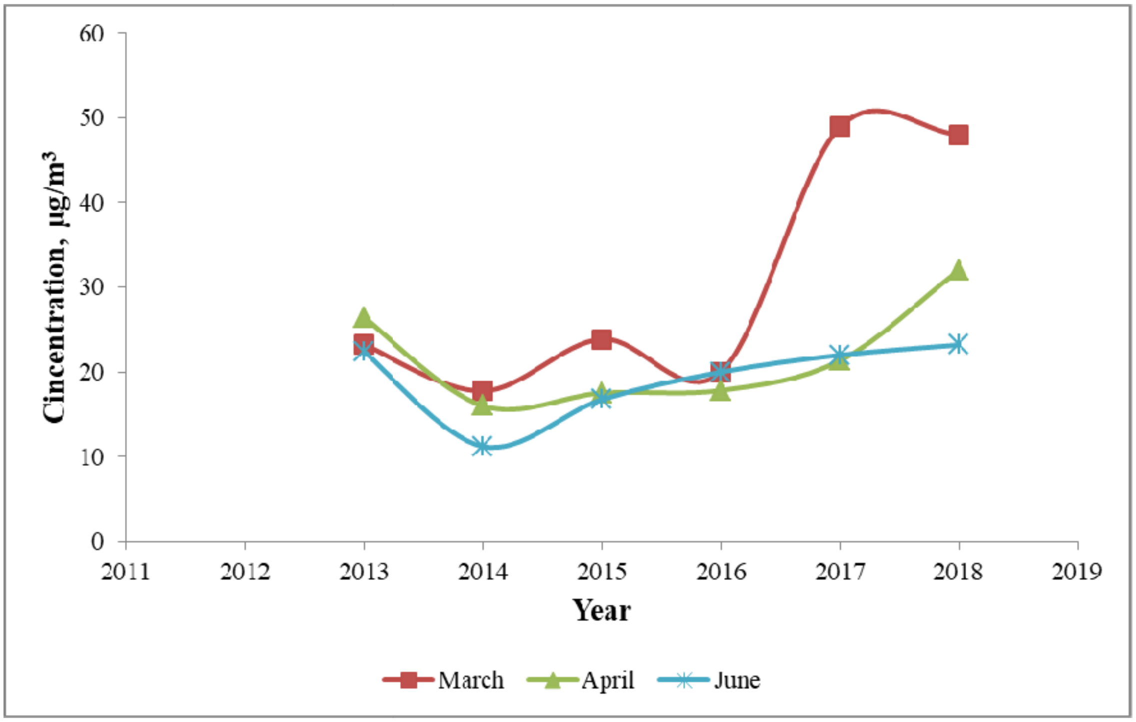

Figure 10: Seasonal trend for NO_2 in Jodhpur industrial cluster

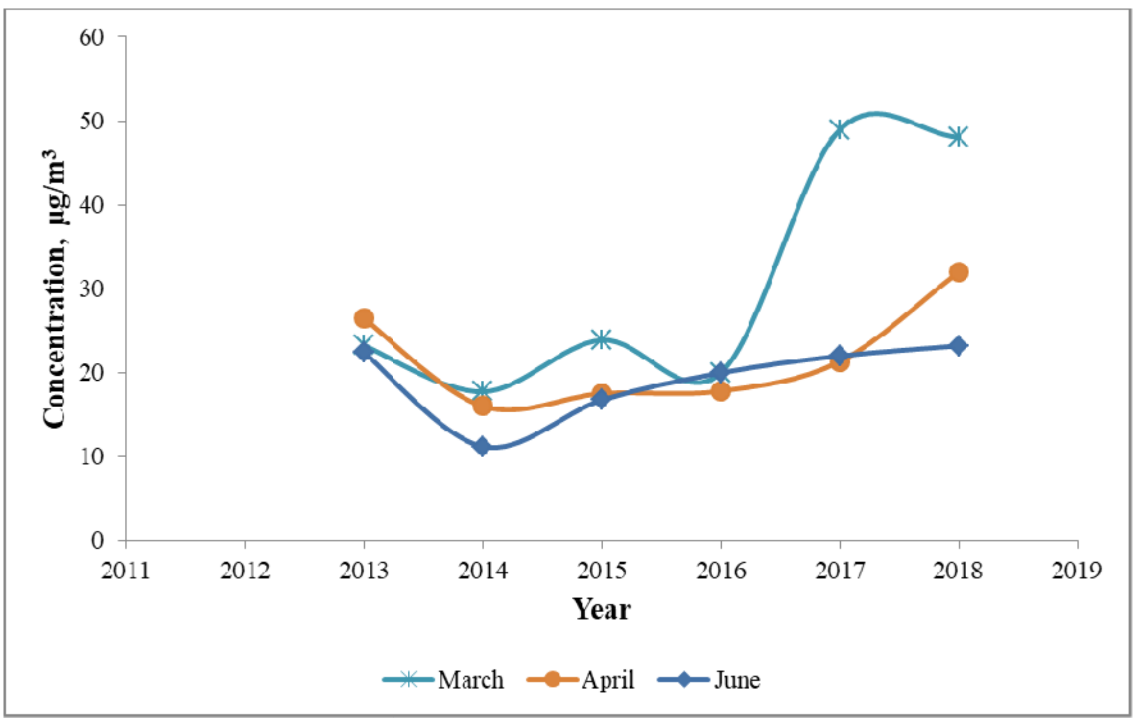

Figure 11: Seasonal trend of $PM_{2.5}$ in Jodhpur industrial cluster

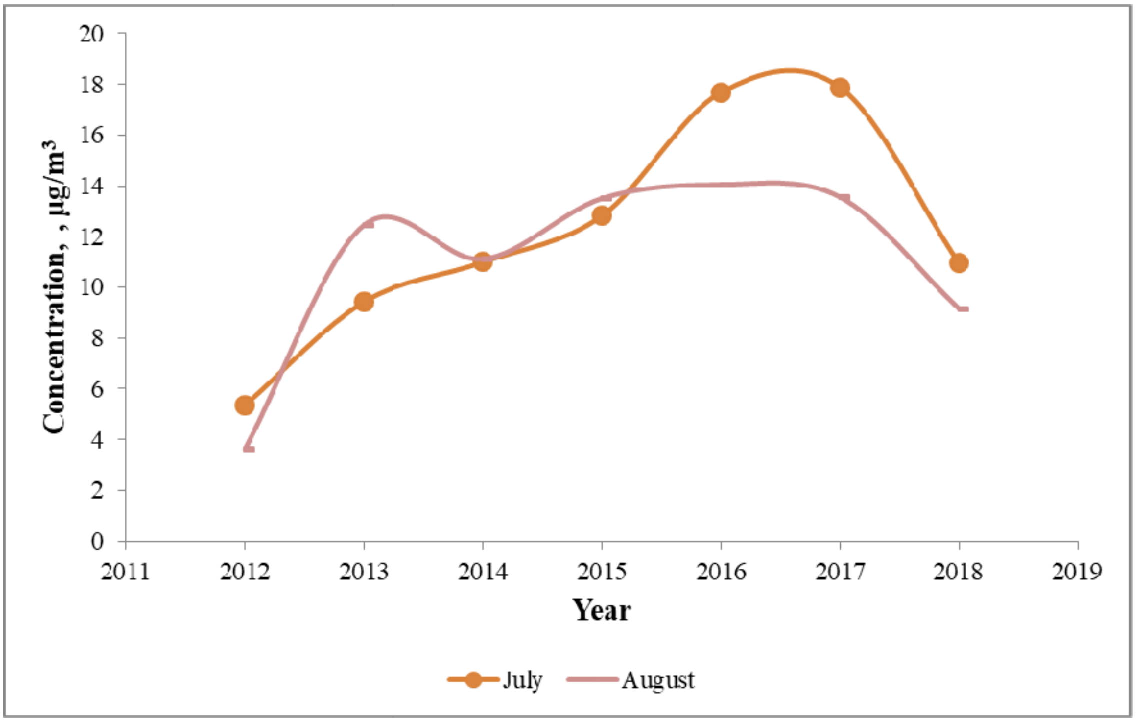

Figure 12: Seasonal trend for NO in Jodhpur industrial cluster

3.2 Water Environment

3.2.1 Major water bodies (Rivers, lakes, ponds etc)and groundwater

Water bodies near Mandore are Jaswandsagar band and springs. Khetnadinadi flows through the impact area of Bornada. Jojari River flows through BNPH, Basni, Salawas and Sangaria industrial areas and is reported as polluted. Within 5kms impact zone of Heavy / Light Industrial Area and BNPH is the Takt Sagar Lake, which is a major water body in Jodhpur.

(Chouhan et al. 2017) measured various parameters in water samples from various tube-wells located on the bank of Jojari river, namely, pH ,Total Dissolved Solids (TDS), Na+ , Ca2+ ,Mg2+ ,K+ ,P+ to assess pollution due to the dumps of textile industry sludge on river bed. They also assessed the concentrations of heavy metals like Ni, Pb, Zn, Cr, Cd etc. using Inductive coupled plasma- Optical emission Spectrometer (ICP-OES) in water as well as sludge samples from the bed of river Jojari. The results indicated that leaching of deposited metals is taking place continuously and has currently polluted upper level of ground water, while deep underground water was not affected perhaps due to the presence of impermeable layer of soil at a certain depth. But this has a high propensity to contaminate deep layer of ground water in future and hence urgent measures would be required to scientifically manage the sludge. In a similar study, (Agarwal et al. 2017), samples of underground water collected along the Jojri river showed high concentration of fluoride, which was attributed to leaching from high fluoride containing effluent from steel industries. This calls for immediate measures to treat the wastewater generated from industries for fluorides before discharging it into the river.

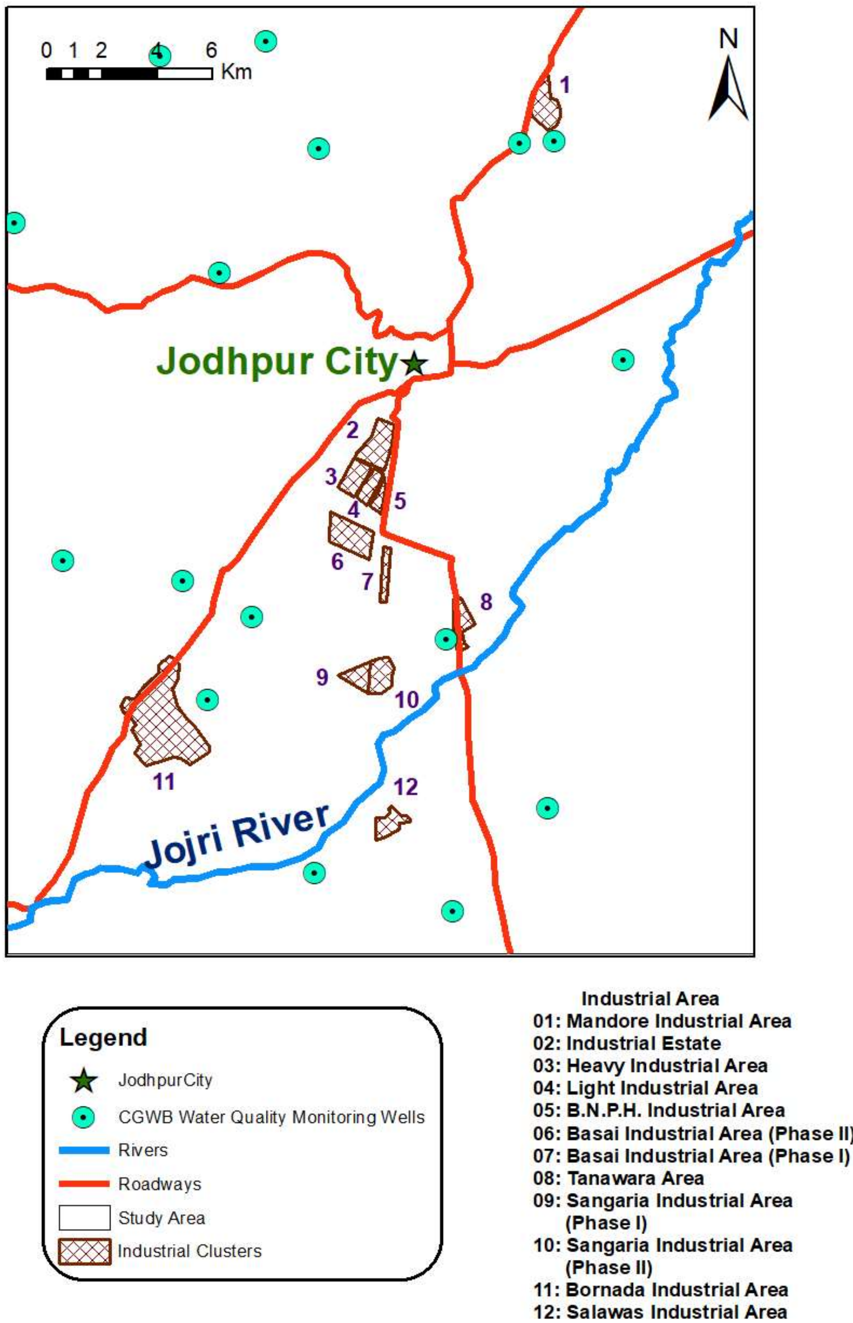

Figure 13: Location of CGWB water quality monitoring wells in Jodhpur industrial cluster

Groundwater quality data of observations wells of State Ground Water Board and Central Ground Water Board has been obtained from CGWB. Location of CGWB wells is shown in Fig. 13.

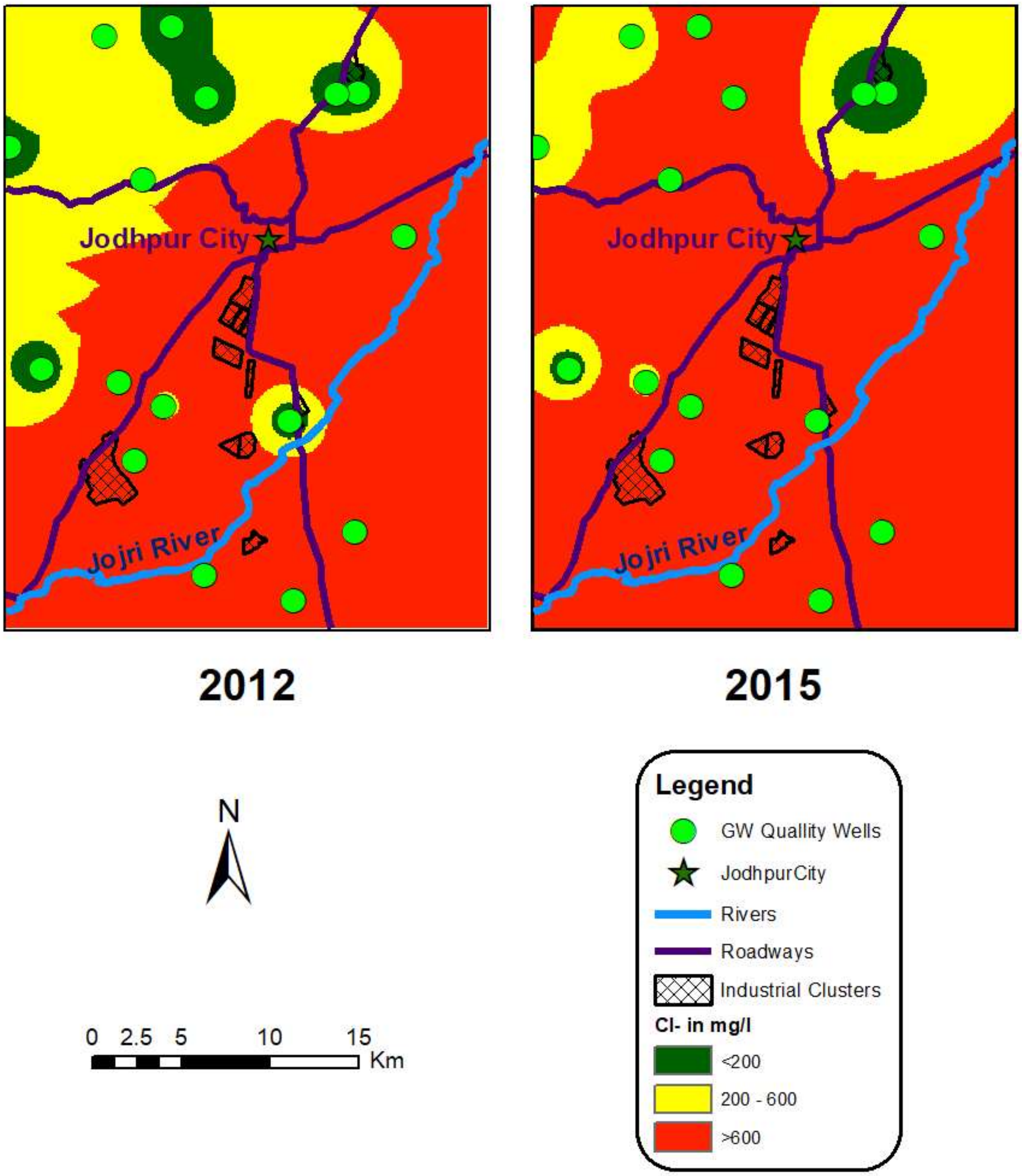

Figure 14: Map showing groundwater quality in terms of chlorides in the study area

We have generated the concentration contours based on the available groundwater data for various quality parameters, which indicate that the high fluoride belts were close to both sides of the Jojari river basin in 2012, however the south-east parts of the basin showed relatively higher contamination in 2015(Fig. 14-18).

For groundwater, maps showing contours reflecting different concentrations of environmental parameters have been prepared for years 2012 and 2015. For a year, a plot indicates the relative concentrations of a specific environmental parameter e.g. chlorides in the study area. The comparison over time reflects the attenuation or augmentation for a parameter in a particular part of study area.

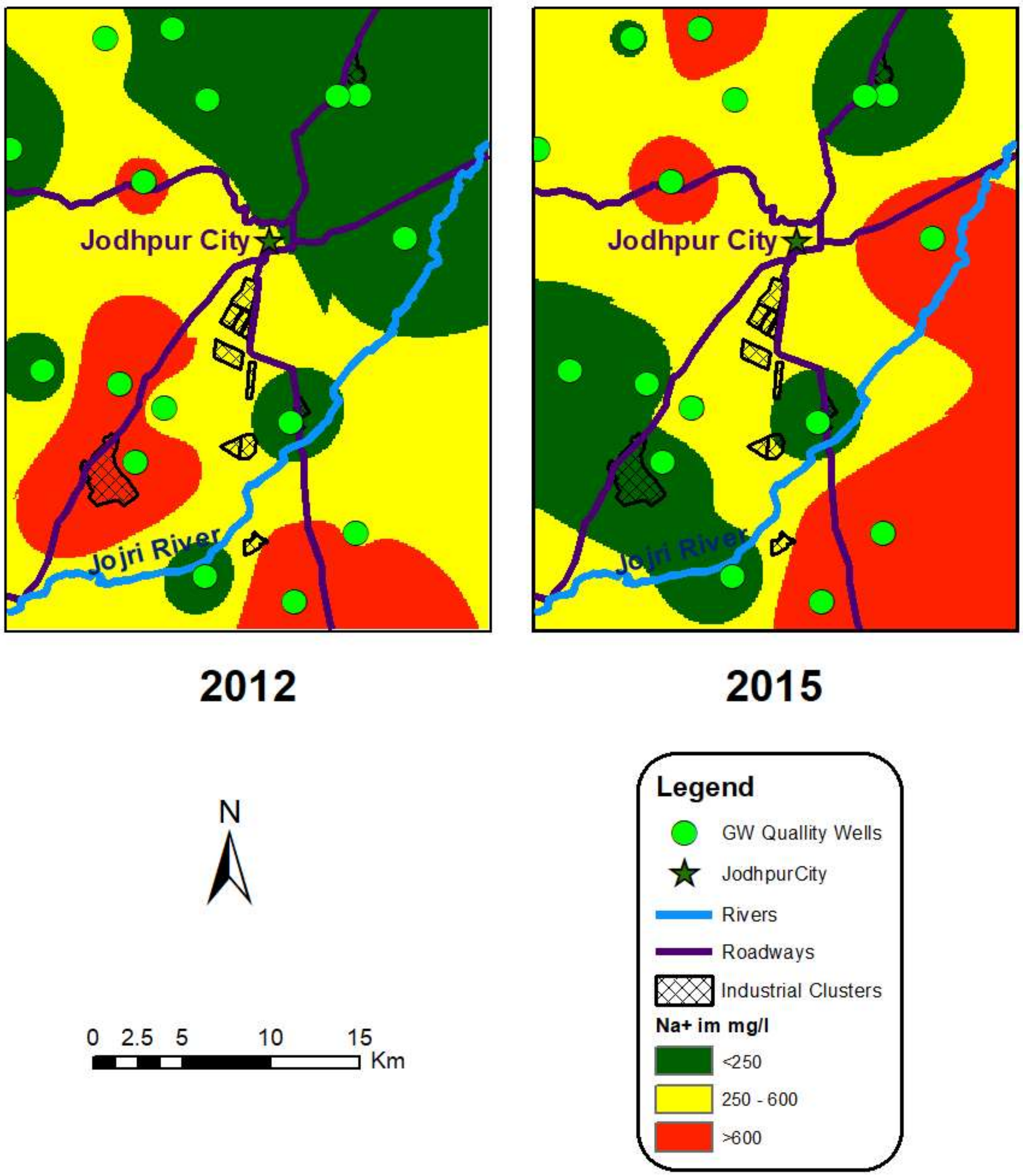

Figure 15: Map showing groundwater quality in terms of Na+ ions in the study area

Figs. 14 to 18 show the interpolated maps of groundwater quality of Jodhpur study area for years 2012 and 2015 in terms of chlorides, sodium ions, Sodium absorption ration (SAR), sulphate and TDS. Interpolated maps are obtained based on groundwater quality data of observations wells. Interpolation is carried out using Inverse Distance Weighted algorithm and values are classified into different groups based on Indian Standard. For example, TDS maps are classified with green colour, where TDS values are lower than 500 mg/l, yellow colour where TDS values are between 500mg/l and 2000mg/l and red colour where values are greater than 2000 mg/.

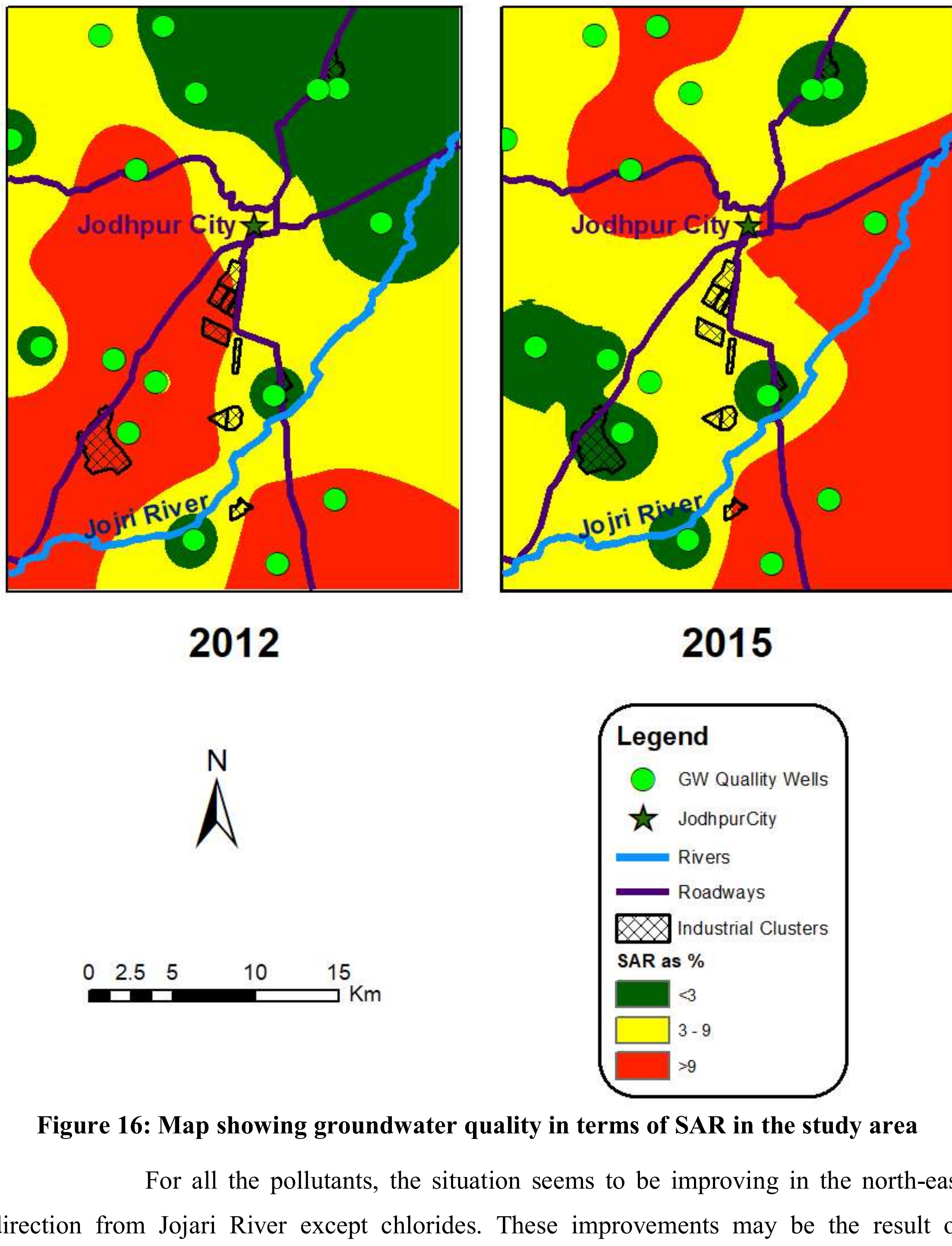

Figure 16: Map showing groundwater quality in terms of SAR in the study area

For all the pollutants, the situation seems to be improving in the north-east direction from Jojari River except chlorides. These improvements may be the result of measures undertaken in the past e.g. installation of PETPs, CETP and STPs in the study area. On the other, chloride is a conservative pollutant and does not attenuate by being sorbed to the sediments.

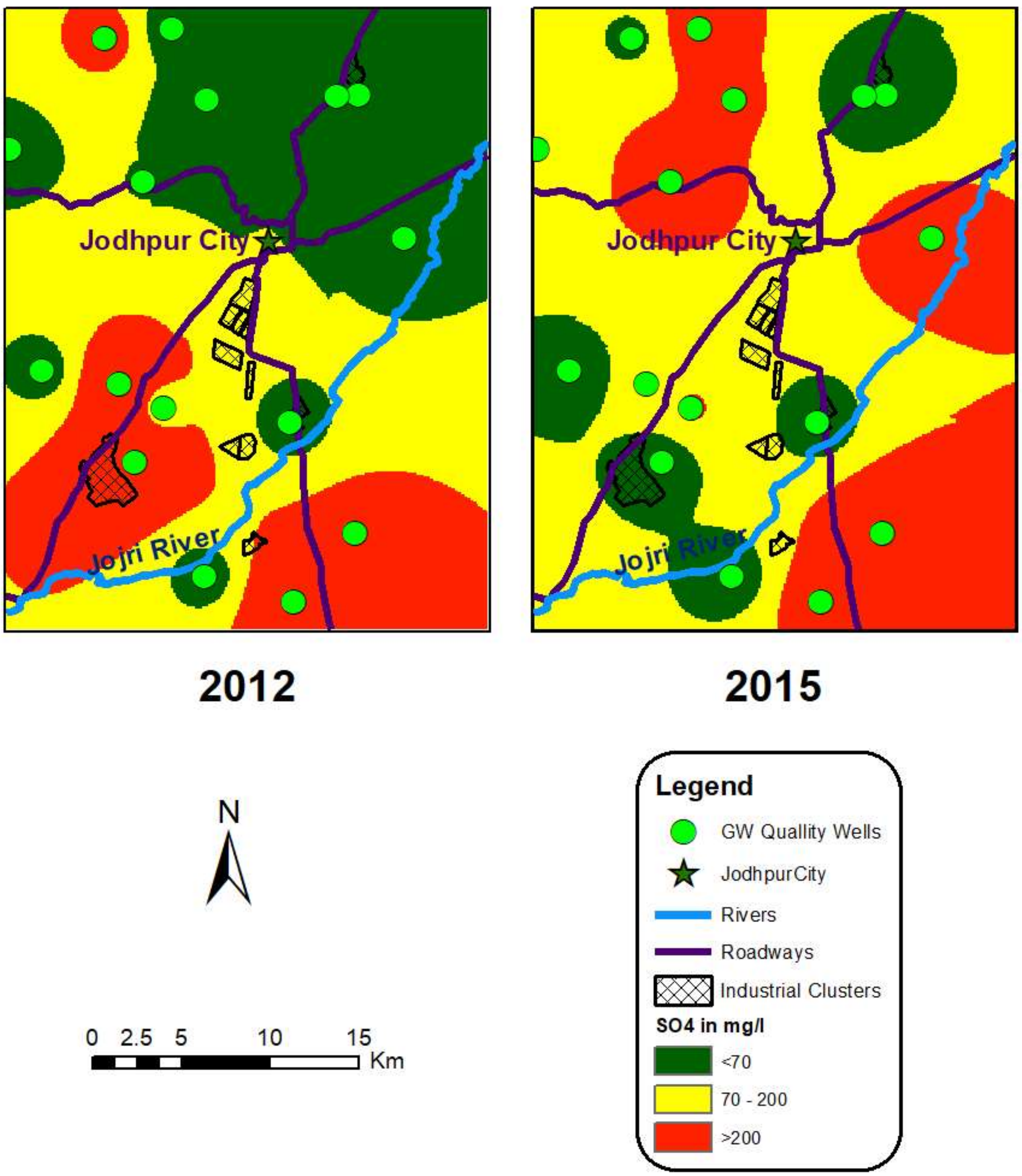

Figure 17: Map showing groundwater quality in terms of sulfate in the study area

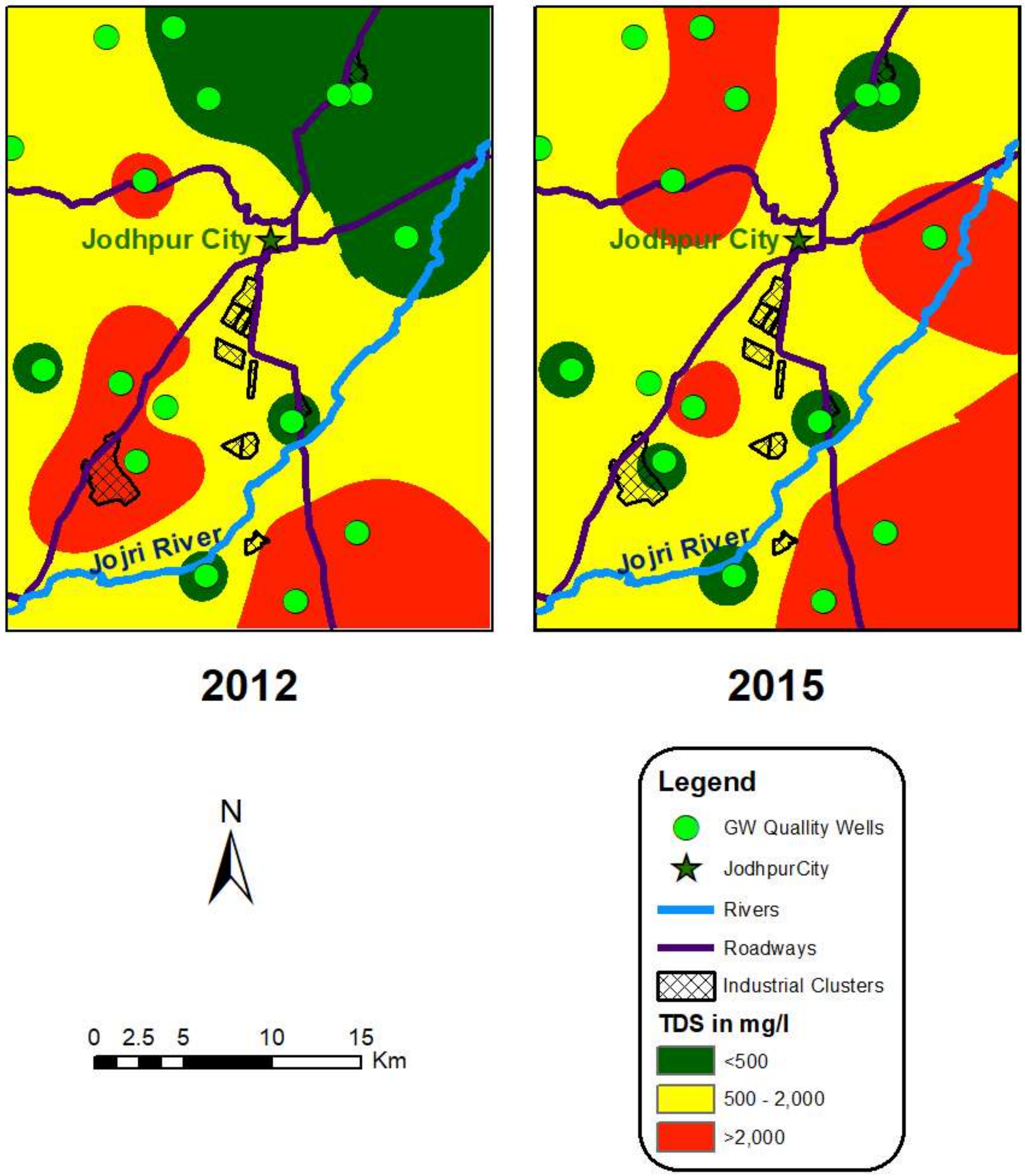

Figure 18: Map showing groundwater quality in terms of TDS in the study area

3.2.2 Trends for water quality

The monitoring wells installed by Central Ground Water Board (CWGB) have been shown in Fig. 13. Figs 19-23 depict the trends of groundwater quality in Jodhpur industrial cluster for the following pollutants: TDS, Sulfate, Nitrate, Total Alkalinity and Ammonia. Again, one of the striking features in these plots is the dip in Ammonia concentration in groundwater in year 2018. This, again, may be the result of reduced emissions of Ammonia in the region as a result of industry closure. In fact, the presence of high levels of TkN and ammoniacal nitrogen indicates a direct impact of industrial discharges as they contain nitrogenous salts.

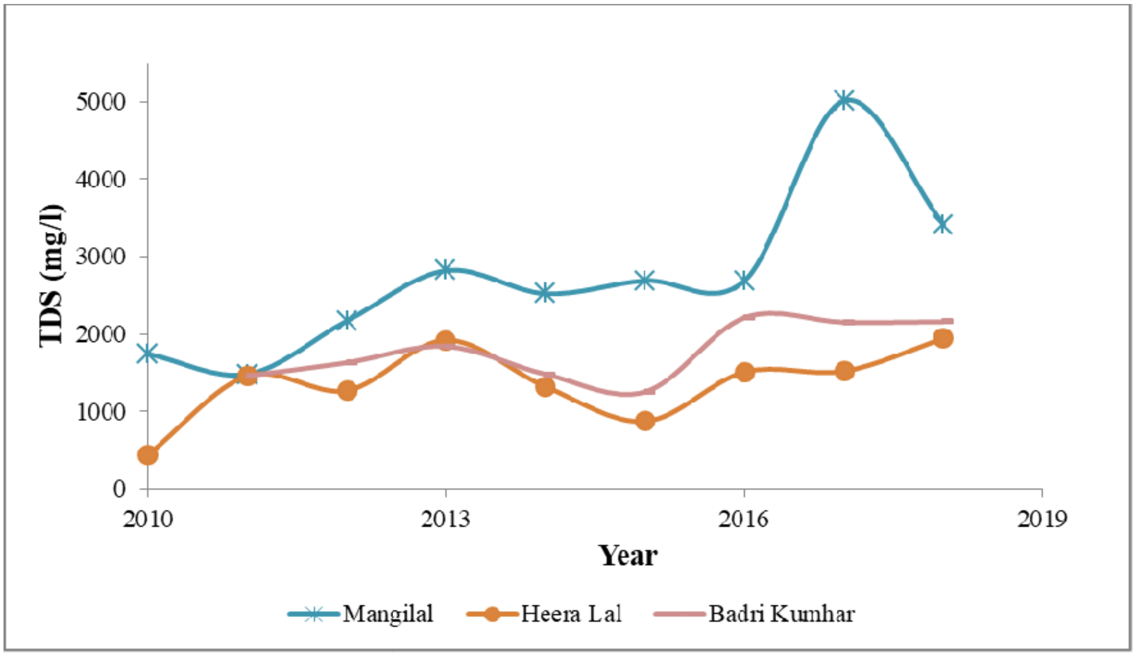

Figure 19: Trend of TDS in groundwater at Jodhpur

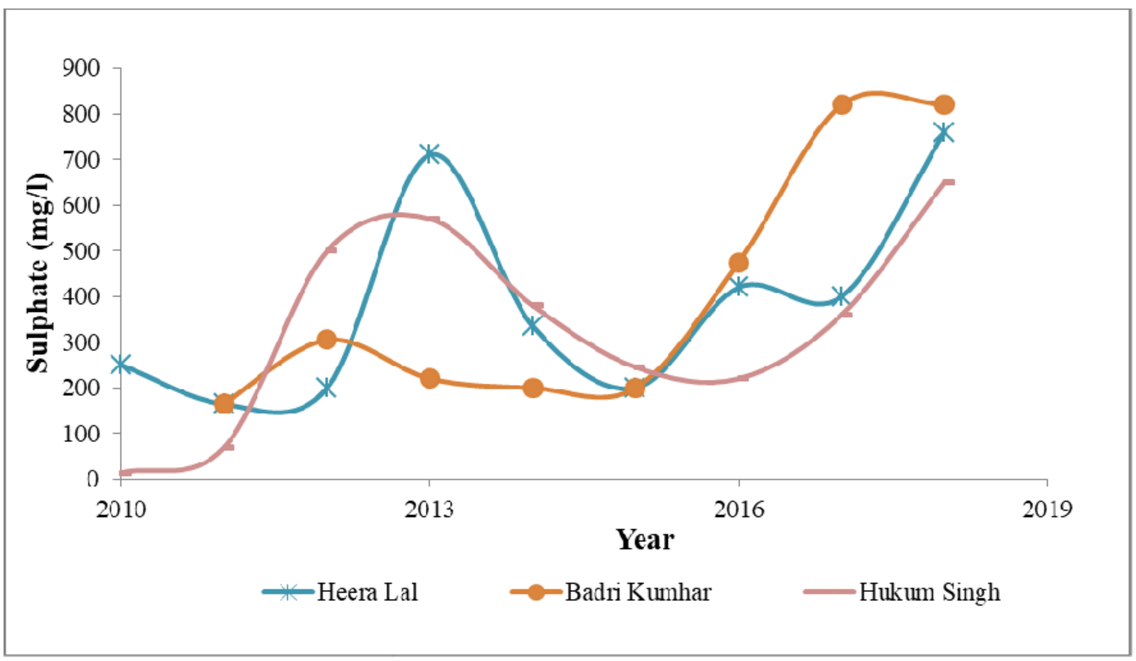

Figure 20: Trend of sulphate in groundwater at Jodhpur

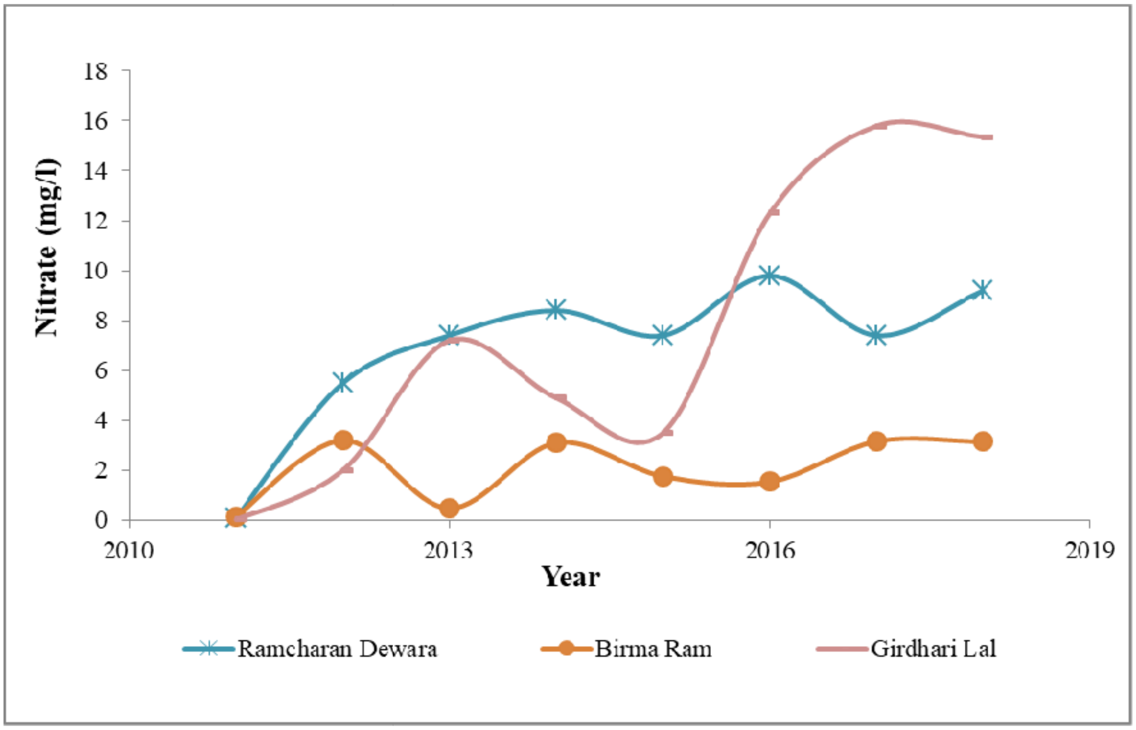

Figure 21: Trend of Nitrate in groundwater at Jodhpur

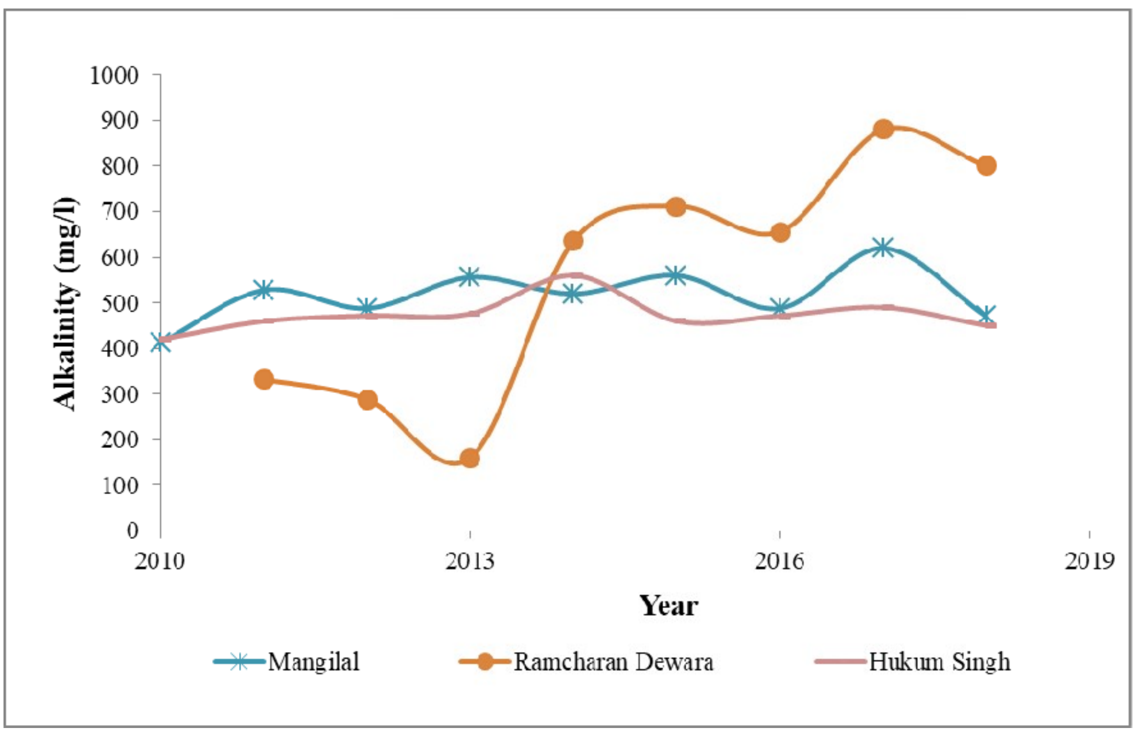

Figure 22: Trend of total alkalinity in groundwater at Jodhpur

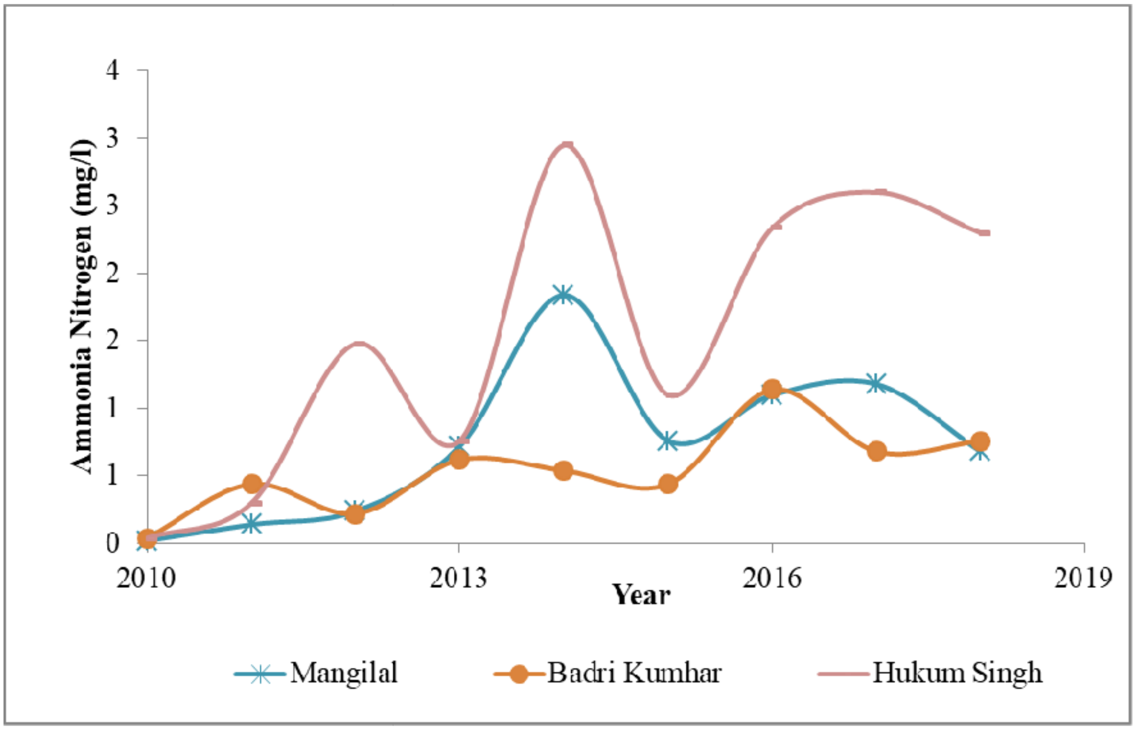

Figure 23: Trend of Ammonia Nitrogen in groundwater at Jodhpur

3.3 CEPI Score

3.3.1 CEPI Score with original methodology

Jodhpur City and industrial areas have been classified as critically polluted area with the CEPI score of 75.19 as per the report prepared by CPCB for the Jodhpur Industrial Cluster. The report ranks Jodhpur as the 23rd most polluted city in the list of critically polluted industrial clusters in India. Following table (Table 2) gives the parameter-wise CEPI scores for Jodhpur.

Table 2: Scores for Jodhpur industrial cluster for year 2013 (PDCORE and IL&FS 2013) and Year 2018 (as per communication with CPCB officials)

Year	Air	Water/ Surface water@	Land/ groundwater@	CEPI
2013	52	65.5	54	75.19
2018	67	66	65	81.16

@as per communication with CPCB officials, it was clarified that the water and land in the original CEPI framework correspond to surface water and groundwater components in modified CEPI

As per information obtained from RPCB, we find that PM_{10}, $PM_{2.5}$ and NO_x were taken as the criteria pollutants for estimating the CEPI. However, as per the philosophy of CEPI, we have to assume a primary parameter, which is a signature pollutant for the industries of concern. It is to be pointed out that the major industrial clusters in Jodhpur belong to textile dyeing & printing and steel industries. The contribution of these industries to PM_{10} and/or $PM_{2.5}$ would be minimal. Although, the concentration of PM_{10} is observed as high but its role as a signature pollutant for CEPI calculation was discarded as its origin does not lie in the industries (MHIPE 2018)(USEPA 2014). Ammonia is a major pollutant for textile industries and hence serves the purpose of estimating CEPI for industrial clusters (Sarayu and Sandhya 2012). Sulfates and TDS also get emitted from industries in substantial quantities (Sarayu and Sandhya 2012). In fact, textile industries process raw cloth at a high pH and lot of ammonium salts are used in different steps leading to emissions of ammonia, which is a pH driven reaction:

$$NH_3 + H^+ = NH^+_4$$

Thus free ammonia is liberated at high process pH from these units, which is evident not only from its relatively high concentration in ambient air than other cities (though still well within the ambient standards), the wastewater, when disposed of, has resulted in high concentrations of TKN and NH_4-N in groundwater. Despite the fact that the major contributions for ammonia in atmosphere are considered as emissions from agriculture and animal sources as well as from vehicles, the textile cluster is also contributing to it significantly.

Furthermore, Ammonia is a major contributor to secondary aerosol formation in the atmosphere. Ammonia reacts rapidly with both sulfuric and nitric acids to form fine particles.

$$NH_3 + H_2SO_4 => NH_4HSO_4 + NH_3 => (NH_4)2SO_4$$

$$NH_3 + HNO_3 <= => NH_4NO_3$$

Steel industries, on the other hand, emit lot of acid mist near the pickling area, which is generally not monitored and is an occupational hazard. Thus we suggest the inclusion of NH_3 as the primary gaseous pollutant and $PM_{2.5}$ (fine aerosol due to atmospheric reactions of ammonia) and NO_2 as secondary parameters for CEPI calculations. We have prepared the following table to indicate large variations in CEPI calculations with different sets of parameters to stress upon the aforementioned point.

The pollutants selected for CEPI estimation of Jodhpur industrial cluster are NH_3, $PM_{2.5}$, and NO_2 for air; Cr, BOD and Pb for surface water; NH_3, TDS, SO_4^{-2} for land. The CEPI scores for Jodhpur industrial cluster have been first calculated based on the original methodology and provided in Table 3. The scores have been calculated for various scenarios in total taking into account different pollutants or order of pollutants for each scenario. For scenarios 1-11, data were taken for Jojari river (situated downstream from the industrial cluster) for water component. For scenario 12, data has been taken for Kailana lake (situated upstream from the industrial cluster).

Table 3: CEPI Scores with original methodology of Jodhpur for different pollutants (year 2019)

S. No.	Air	Water	Land	Air	SW	GW	CEPI Score
1	$PM_{2.5}$, NH_3, O_3,	Cr, BOD, Pb,	NH_3, TDS, SO_4,	70	79	60	87.7
2	NH_3, O_3, $PM_{2.5}$	Cr, BOD, Pb,	NH_3, TDS, SO_4,	58	79	60	86.1
3	$PM_{2.5}$, NH_3, O_3,	Cd, BOD, Pb	NH_3, TDS, NO_3^-	70	79	65	88.4
4	NH_3, O_3, $PM_{2.5}$	Cr, BOD, Zn	NH_3, TDS, Cl^-	70	70	60	82.6
5	NH_3, O_3, $PM_{2.5}$	BOD, Pb, Cr	NH_3, NO_3^-, Cl^-	70	65	65	82.7
6	NH_3, O_3, $PM_{2.5}$	Cr, BOD, Pb,	NO_3^-, Cl^-, SO_4,	70	79	60	87.7
7	PM_{10}, NH_3, O_3,	Cr, BOD, Pb,	NH_3, TDS, SO_4,	73	79	60	88.1
8	NH_3, O_3, PM_{10},	Cr, BOD, Pb,	NH_3, TDS, SO_4,	58	79	60	86.1
9	NO_2, NH_3, O_3	Cr, BOD, Pb,	NH_3, TDS, SO_4,	69	79	60	87.5
10	NH_3, $PM_{2.5}$, NO_2	Cr, BOD, Pb,	NH_3, TDS, SO_4,	58	79	60	86.1
11	$PM_{2.5}$, NO_2, NH_3,	Cr, BOD, Pb,	NH_3, TDS, SO_4,	96	79	60	98.3
12	NH_3, $PM_{2.5}$, NO_2	NH_3, TDS, SO_4,	NH_3, TDS, SO_4,	58	44	60	70.2

The scenarios involve changing type of pollutants as well as their order for air and groundwater components only. The EPI scores for air vary from 58 – 96, whereas for water and landthe variation is from 44 – 79 and 66 – 68 respectively.

For each of the components i.e. air, water and land, the causes for the resulting scores are different. For air, pollutants were present in widely varying concentrations in terms of their exceedance from the standards and hence there was a wide variation in the scores. On the other hand, majority of the pollutants (especially the ones considered for calculation) in groundwater exceeded the standards by larger margins and thus the scores were in a narrow range for different pollutants. For surface water, the data used were from Jojari river (11 cases) and Kailana lake (1 case). Both the datasets have limitations. Kailana lake is situated upstream from the industrial cluster and hence does not represent the contamination by pollutants from the industrial cluster. Jojari river is a seasonal river and carries only the excess rainwater. In case of dry season, the river only carries treated and untreated effluent and wastewater and thus cannot reflect a surface water body being contaminated by the industrial effluent.

3.3.2 CEPI Score with revised methodology

Recently CPCB and IIT Delhi have modified the methodology to calculate CEPI (CPCB 2016). Subsequently, CEPI scores were calculated following the modified methodology (Table 4; Figs 24-27). Scores for different scenarioswere estimated again considering different pollutants and changing their order. Similar to the calculations for original CEPI methodology, data were taken for Jojari river (situated downstream from the industrial cluster) for water component for scenarios 1-11. Data from Kailana lake (situated upstream from the industrial cluster) were employed for scenario 12.

Table 4: CEPI Scores with revised methodology of Jodhpur for different pollutants combinations for year 2019

S. No.	Air	Surface Water	Ground Water	Air	SW	GW	CEPI Score
1	NH_3, O_3, $PM_{2.5}$	Cr, BOD, Pb,	NH_3, TDS, SO_4,	50	71	66	80
2	$PM_{2.5}$, NH_3, O_3,	Cr, BOD, Pb,	NH_3, TDS, SO_4,	71	71	66	85
3	NH_3, O_3, $PM_{2.5}$	Cd, BOD, Pb	NH_3, TDS, NO_3^-	50	71	67	80
4	NH_3, O_3, $PM_{2.5}$	Cr, BOD, Zn	NH_3, TDS, Cl^-	50	69	66	80
5	NH_3, O_3, $PM_{2.5}$	BOD, Pb, Cr	NH_3, NO_3^-, Cl^-	50	68	68	79
6	NH_3,O_3, $PM_{2.5}$	Cr, BOD, Pb,	NO_3^-, Cl^-, SO_4^-	50	71	69	81
7	NH_3, O_3, PM_{10}	Cr, BOD, Pb,	NH_3, TDS, SO_4,	48	71	66	80
8	NH_3, O_3, NO_2	Cr, BOD, Pb,	NH_3, TDS, SO_4,	50	71	66	74
9	NO_2, Benzene, PM_{10},	Cr, Zn,, Cd	NH_3, TDS, SO_4,	81	73	66	90
10	NH_3,$PM_{2.5}$, NO_2	Cr, BOD, Pb,	NH_3, TDS, SO_4,	60	71	66	82
11	$PM_{2.5}$, NO_2, NH_3,	Cr, BOD, Pb,	NH_3, TDS, SO_4,	79	71	66	89
12	NH_3,$PM_{2.5}$, NO_2	NH_3,TDS,SO_4 ,	NH_3, TDS, SO_4,	60	46	66	76

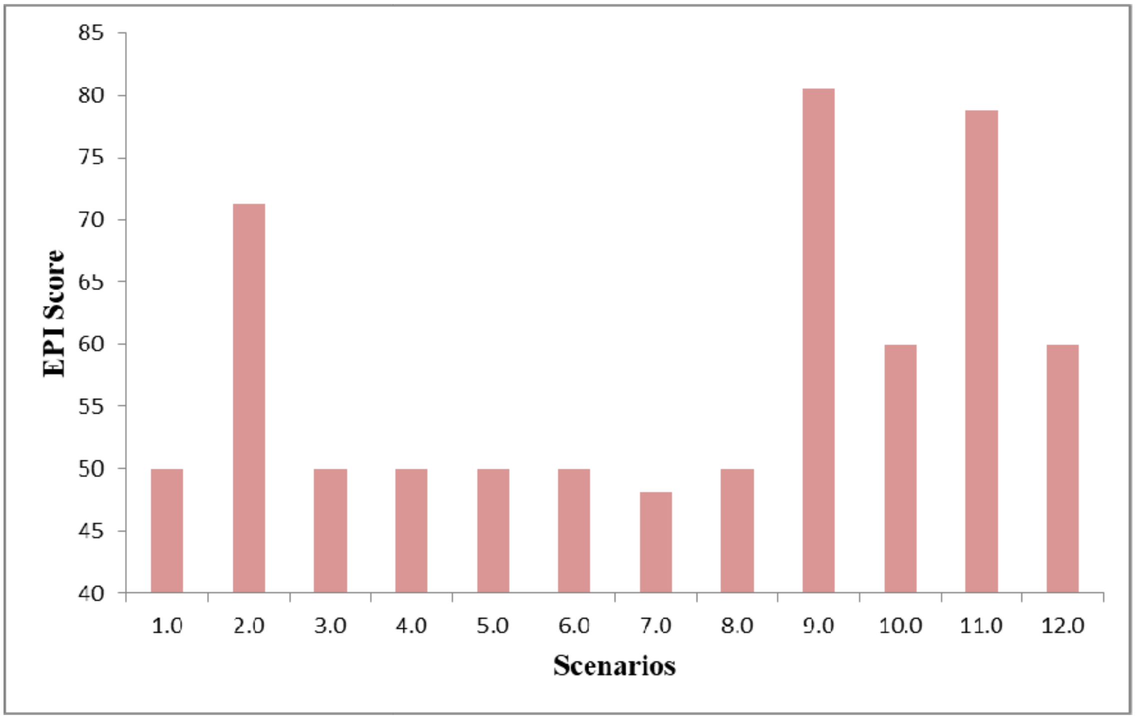

Figure 24: Variation in EPI score of Air for different pollutants

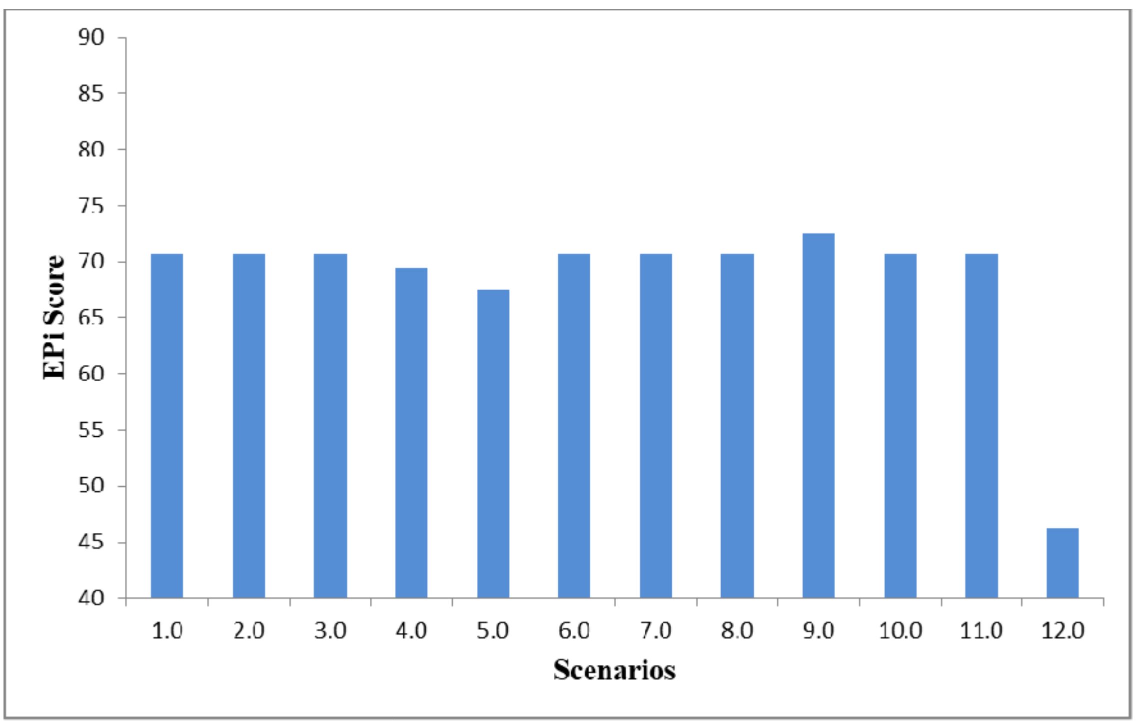

Figure 25: Variation in EPI score of surface water for different pollutants' scenarios

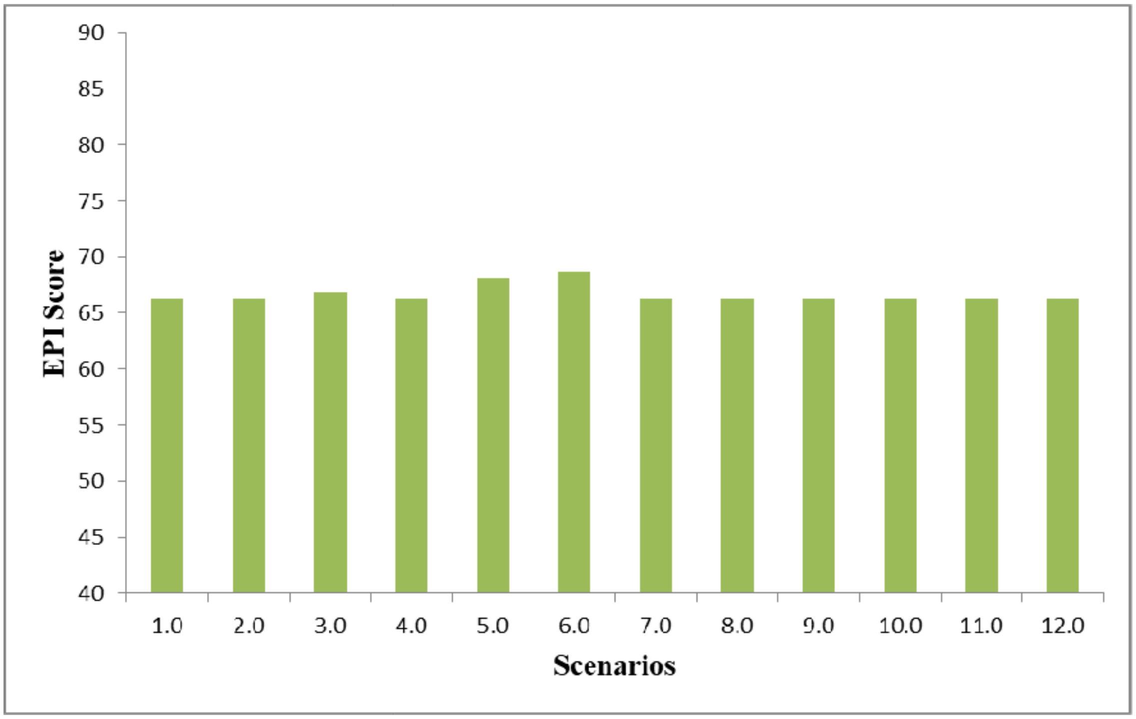

Figure 26: Variation in EPI score of GW for different pollutants

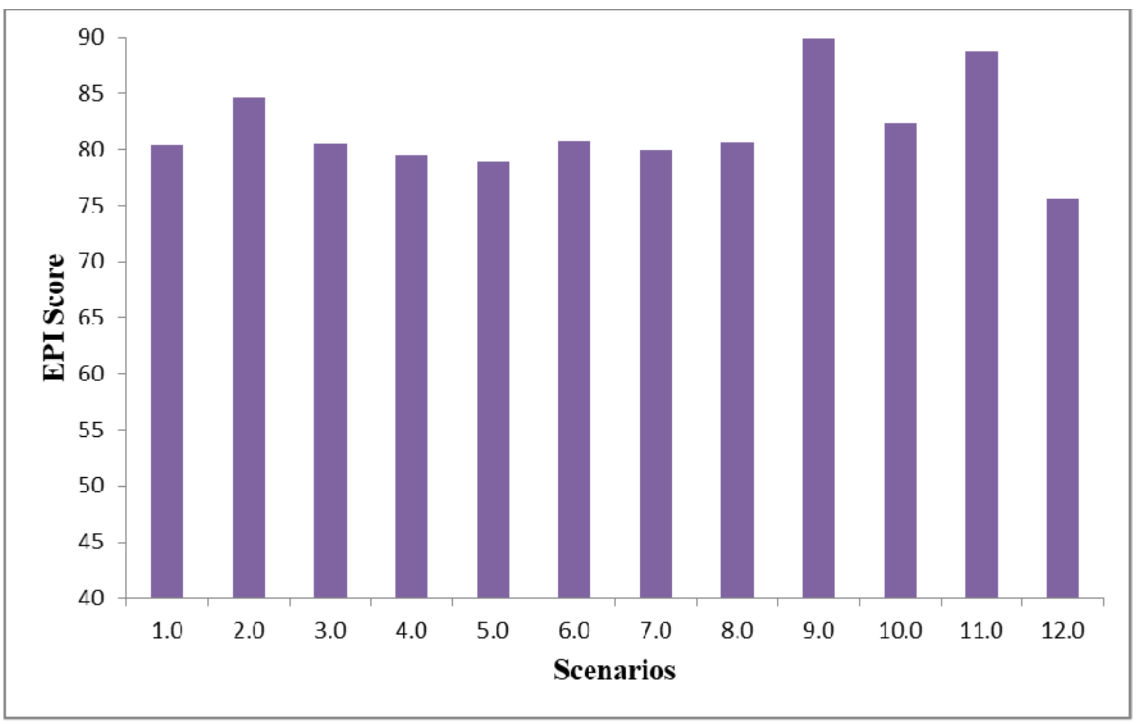

Figure 27: Variation in CEPI score for different pollutants

In case of revised methodology, the EPI scores for air varied from 48 – 81, whereas for water and land it varied from 46 – 73 and 66 – 69 respectively.

As the same data set was used for calculation, the causes of the resulting scores of EPI are similar as in case of original methodology. For air and groundwater, it was the pollutants' concentration responsible for the wide variation and narrow range respectively. For surface water, the dataset was suffering from the same limitations as discussed above.

From the above discussion, the following can be inferred:

- It was observed that data for heavy metals and pesticides were not available except for Jojari River. While collecting the data, the data for carcinogens like heavy metals and pesticides should also be collected by the government agencies to assess any long term health implications of pollution.
- As the methodology of the CEPI calculation depends on the exceedance factor, the concentration of the pollutants is a major factor. Hence the pollutants selected and their order are very important in calculating CEPI score.
- The comparison should be made only between similar type of methodologies e.g. scores from original CEPI methodology should be compared with the scores from revised CEPI methodology, as the two approaches are widely different.

4. ACTION PLAN FOR JODHPUR INDUSTRIAL CLUSTER

4.1 Summary of Proposed Action Points

Short Term Action Plan- Air

S. No.	Action points (Including source and mitigation measures)	Suggested Responsible stakeholders/Agency involved	Remarks
1.	Performance monitoring of major air polluting industries for assessment of compliance of the notified air emission standards.	RSPCB, Industrial Association	-
2.	Implementation of Traffic Master Plan	Traffic Police	--
	a. Introduction of one way traffic in selected areas to reduce the traffic density	Traffic Police	
	b. Banning entry of heavy commercial vehicle inside the City to reduce vehicular pollution	Traffic Police	-
	c. Issuing licenses to LPG based autos as per notification dated 22/12/2010	Traffic Police, RTO, District Supply Officer, PWD	-
	d. Continuous monitoring of vehicles by flying squads of transport department to check PUC	Traffic Police, RTO, PWD	-
	e. Regular monitoring of the quality of the fuel being used by the vehicles.	District Supply Officer	-
	f. Periodic education and awareness campaigns for the public, drivers, transporters and other stake holders	Traffic Police, RTO, District Supply Officer, PWD	-
	g. Phasing out of 15 year old commercial vehicles is already in progress. 3,323 autos have been phased till now	Traffic Police, RTO, District Supply Officer, PWD	-
	h. Removal of encroachment on the road side	District Administration/ Jodhpur Development Authority	-
	i. Development of parking arrangements by traffic management near the commercial areas by JDA	Traffic Police / Jodhpur Development Authority	-
	j. Widening of main roads for reducing the traffic congestion and periodic maintenance of Roads	Nagar Nigam/ Jodhpur Development Authority	-
	k. Development of roadside arboriculture	Nagar Nigam/ Jodhpur Development Authority	-
	l. Construction of multi-storeyed/underground parking areas	Nagar Nigam/ Jodhpur Development Authority	-

Long Term Action Plan-Air

S. No.	Action points (Including source and mitigation measures)	Suggested Responsible stakeholders/ Agency involved	Remarks
3.	Installation of additional real Time Continuous Air Quality Monitoring System	RSPCB	Additional continuous Air Quality Monitoring System may be installed to cover all the industrial areas in Jodhpur.

Short Term Action Plan-Water

S. No.	Action points (Including source and mitigation measures)	Suggested Responsible stakeholders/ Agency involved	Remarks
4.	Installation of Flow meter / Water mater with each member unit of CETP trust for monitoring of compliance of the permitted discharge quantity by CETP Trust.	Industrial Association, CETP Trust	Random checking of meters may be carried out. Records for the date of calibration of meters are to be maintained.
5.	Commissioning of additional Sewage Treatment Plant (STP) at Salawas.	RUIDP and Municipal Corporation, JODA	As STP has already been commissioned, sewage reuse should be promoted both for industry as well as for maintenance of green belts in the city in order to reduce the demand for fresh water effectively.
6.	Up-gradation of the sewerage system	RUIDP, Municipal Corporation, JDA	
7.	Cleaning, Desilting & repairs of the open drains for transportation of Untreated industrial effluent to CETP in the industrial area	RIICO, CETP Trust,	Collected silt needs to be disposed properly.

8.	Construction of closed conduit conveyance system for carrying effluent of textile units to CETP	RIICO, CETP Trust and Industrial Association	As majority of the areas have been covered with conveyance system, alternative arrangements may be made where conveyance system is not feasible.
9.	Performance monitoring of CETPs and STPs	RSPCB, CETP Trust and Municipal Corporation	
10.	Monitoring of Groundwater quality	CETP Trust, RGWB	Heavy metals for which dyes have bases, and TkN/NH4-N should be analyzed in addition to routine parameters for all wells close to the Jojari river.
11.	Provision of potable water for affected villages	PHED	All severely affected villages, in terms of groundwater quality, should be connected to any of the existing PHED schemes for the supply of drinking water.

Long Term Action Plan-Water

S. No.	Action points (Including source and mitigation measures)	Suggested Responsible stakeholders/ Agencyinvolved	Remarks
12.	Installation of rain water harvesting system in the buildings and institutions	RIICO, Municipal Corporation , RSPCB	These systemscan be installed wherever feasible. This will help improve water sustainability in the region and can provide low TDS water for the industrial processes. RIICO to ensure that RWH systems are functioning properly and are being made use of.
13.	Construction of the additional CETP for Industries apart from textile & steel industries near Salawas and near Boranada	CETP Trust, RIICO, Industrial Associations and RSPCB	This will enhance the percent coverage of the industries especially the small scale units. RIICO to ensure the progress of additional CETP stays on track.

14.	Reuse and Recycling of treated effluent	Industrial Association and CETP trust	This can reduce the load on CETP substantially.
15.	Construction of the additional STP of 50 MLD capacity at Salawas.	JDA &JMC	Sewage recycle may also be explored along with.

Action Plan-Land

S. No.	Action points (Including source and mitigation measures)	Suggested Responsible stakeholders/ Agency involved	Remarks
16.	Augmentation of Treatment and Disposal facility for Biomedical Waste	Medical and Health Department, RSPCB and Municipal Corporation	-
17.	Disposal of Hazardous Waste	CETP Trust, Industries Department	Reuse should be promoted to the extent possible. The sludge from steel industries would be predominantly inorganic in nature and will contain lot of salts and heavy metals. This has to be disposed of in a scientific manner with some research inputs, e.g., solidification/ stabilization process. A mechanism should be created to pick up solid waste from individual PETPs. The sludge from textile industries should be converted to useful product by mixing it with CETP sludge and some other organic wastes and be utilized by nearby cement plants.
18.	Development of Municipal Solid Waste disposal facility	Municipal Corporation	Facilities for scientific disposal of solid waste should be developed. Then GW monitoring should be performed on a regular basis to indicate any significant contamination due to dumps.

Action Plan-Others

S. No.	Action points (Including source and mitigation measures)	Suggested Responsible stakeholders/ Agency involved	Remarks
19.	Development of green belt and tree plantation in industrial area	Forest Department, Industry, RIICO	Use of treated sewage should be promoted for maintaining the green belt. RIICO to ensure that it is being properly practiced.
20.	Capacity Building for prevention & control of Pollution	RIICO , CETP Trust	Apart from the scientific manpower training, operator trainings may also be conducted for smooth operation of the ETP/STPs. Standard operation procedures should be developed and made available to the operators at site (may be even displayed). Help from research institutions of the area may be taken for these trainings and permissions may be granted to the students to work for their projects to bring out new possible solutions to the problem of waste treatment

Note:

- *These interventions will be implemented by different agencies, including RIICO as identified (tentatively) in the action plan and these agencies should report the progress to the RPCB/Department of Environment (GOR) on a regular basis.*
- *For construction of new STPS and rehabilitations of existing STPs, new schemes formulated by Department of Industry, GoR may be referred to in Appendix.(3)*
- *Inputs from various line departments (provided in Appendix 2) were referred to for preparing the revised action plan.*

4.2 Recommendations for practising long-term sustainability/Research Points:

- In a phased manner some of the big units should establish individual ETPs that comply with the CETP standards making way for smaller units to be completely covered by the CETP. Subsequently efforts must be made to shift them to zero discharge conditions through appropriate measures for recycling and reuse of wastewater as well as sludge in consonance with their social and environmental responsibility.
- In addition to the routine parameters, each ambient air quality monitoring station may be asked to monitor one signature pollutant specific to the area in order to get any clues to the possible sources and hence their abatement measures.

- There is a need to incorporate some signature pollutant(s) for continuous monitoring through SCADA for wastewater from industries.
- Effluent quality parameters, their indications, need for specific modifications in these parameters/the ways for their monitoring etc require some research inputs especially for changes in the wastewater treatment process, where advance oxidation for partial oxidation of dyes followed by biological treatment; or activated sand filtration etc may be attempted.
- The data from real time air quality monitoring systems may be shared with research institutions for further processing in order to bring out some clues for a better management of air pollution and/or identifying some hot spots showing possibilities of episodic conditions besides developing routine charts depicting pollution levels. In addition to what is described above, these data may be analyzed for any clues to the possible sources and hence their abatement measures.
- For steel industries, acid mist may be monitored occasionally in addition to the routine parameters. For monitoring and assessment protocol, research institutions may be approached.
- Any actions taken with regard to traffic should be supported by the trends of pollution levels obtained from the analysis of continuous monitoring data at the RPCB.
- Help may be sought from research institutions for adding more relevant parameters to determine the performance of ETPs.
- With the help of research institutions, it may be explored whether the briquettes made from industrial sludges with the incorporation of some other organic wastes can be used as a fuel for these incinerators for Bio medical waste treatment.

5. FUNDING SCHEMES/POLICIES

Funding for Support/Facilities is provided by Industries Department through various schemes such as:

1. Rajasthan NiveshProtsahanYojna (RIPS) 2014 and 2019

   Provides capital Subsidy on Zero liquid discharge based treatment plant.

2. Rajasthan MSME Policy 2015

   To encourage MSMEs/Handicraft/Handloom enterprises to attain international quality benchmark, the state government will endeavour to establish national laboratories. A 50% rate of DLC will be given to MSMEs setting Research, Development and testing laboratories.

3. Integrated Textile Processing Development scheme (IPDS)

   The primary objective of the IPDS is to facilitate the textile industry to become globally competitive using environmentally friendly processing standards and technology. The IPDS would facilitate the textile industries to meet environmental standards, create new processing parks, support the upgradation of existing clusters and promote R&D in the area of W&WW management.

4. Rajasthan Integrated CETP scheme (under discussion)

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Appendix

Inputs from various line departments