Agricultural Activity and Water Quality in India

Serena Doose[1], Eric Eaton[1], Alexa Rancourt[2]

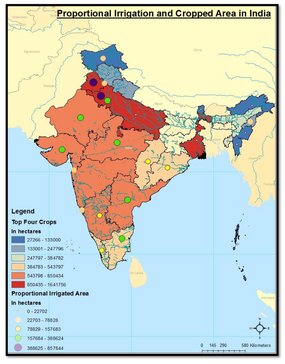
[1]Earth and Environmental Science, [2]Philosophy, Furman University, Greenville, SC 29613

Abstract

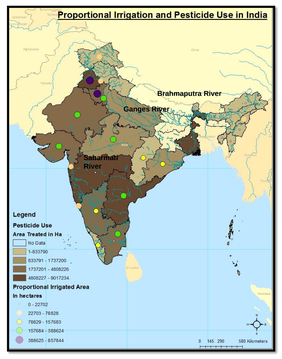
Water quality and contamination problems are huge issues in India. As most agricultural areas are concentrated around water sources such as rivers and streams, the status of both are highly interconnected. The primary objective of this project is to analyze the relationships between high levels of agricultural activity among different river basins and the water quality in the corresponding rivers, using indicators such as pH and dissolved oxygen. Looking at variables such as total livestock, different types of crop production, fertilizer use, pesticide use, irrigated area, total cropped area, and groundwater recharge rates, we were able to visually examine whether or not there were relationships between agriculture and water quality parameters. We found that higher agricultural production was typically accompanied by high fertilizer and pesticide use. Analyzing the water quality of the Ganges, Sabarmati, and Brahmaputra Rivers, we determined that high levels of agriculture tend to result in reduced levels of water quality in surrounding river basins. These findings indicate negative ecological and health effects associated with large scale pesticide and fertilizer use.

Background

Since the Green Revolution in the 1970s, crop production in India has greatly intensified. Due to the implementation of new agricultural technology, use of fertilizer, pesticide, and irrigation have become far more prevalent. Though there are considerable benefits such as increased crop yields and decreased famine occurrence due to the new technology, there have also been adverse effects on both human health and the state of the environment. Fertile land, primarily used for agriculture, is often found near streams and rivers, creating a close connection between agricultural activity and health of the water system. Therefore, surface water can easily be contaminated by pesticide and fertilizer runoff, while groundwater quality can be compromised by over application of chemicals and high irrigation use. Also, ingestion of water contaminated by fertilizers such as phosphorous and nitrogen can lead to a multitude of health problems, including mental retardation, cancer, and organ damage. Many environmental problems in India result from high agricultural activity near ecologically sensitive areas such as watersheds and river basins.



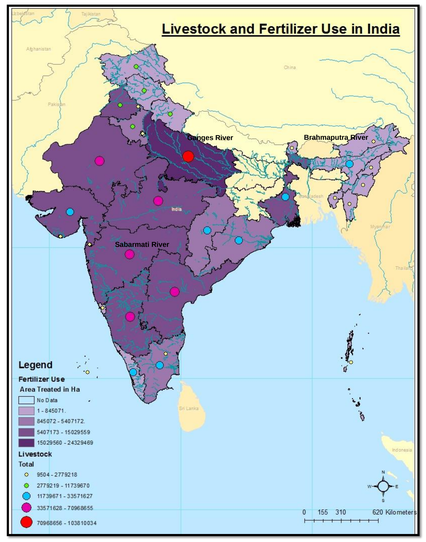
This map shows total cropped area compared to total irrigated area proportional to total state area. States need large quantities of irrigated water to grow large amounts of crops, as seen on our map.



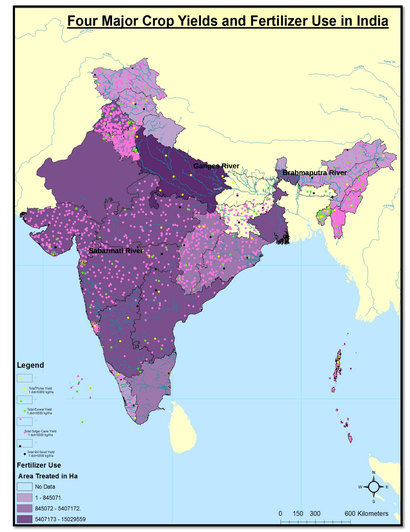
This map demonstrates the proportion of irrigated area to state area and total area treated by pesticides in hectares. States that irrigate high quantities of water, proportional to their size, are often states with heavy pesticide use, creating a potential health risk.

Methodology

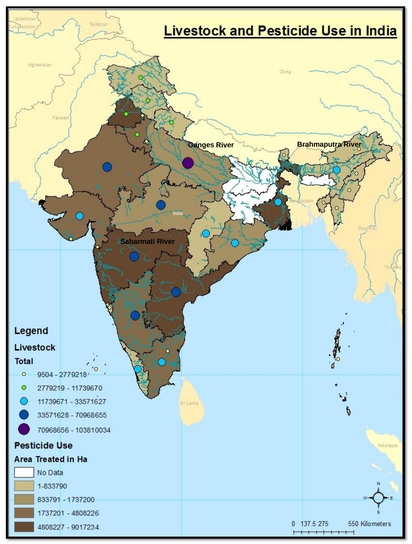
Initially, we analyzed all of the data from the different categories and created a list of variables that we wanted to be expressed visually. With this list, we were able to decide which spreadsheets of data we wanted to join with the India State Shapefile. We fixed our data so that all the spreadsheets of collected data would be able to be joined to the State Shapefile based on ID number. We eventually decided that the amount of irrigation per state, total cropped area per state, total usable groundwater per state, and amount of pesticides and fertilizer used per state were most important to visualize. (An important aspect of total cropped area and irrigated area per state is that we divided these factors by total area of the state to help further understand relationships between crop growth and amount of irrigation).We joined the tables to the India state shapefile and exported the joined table as a new shapefile for each set of data. Then, we symbolized the new layer to show variances in data across India. On top of these layers, we imported data concerning production of the top four crops in India. Following a similar sequence of steps, we mapped the distribution of these four crops using dot density distribution. We were careful to keep the amount of hectares of crops to dot ratio the same for all four crops so an objective comparison between them could be understood. We used proportional symbol symbology to map irrigation and gradual colors to map fertilizer use, pesticide use, and groundwater distribution. Finally, we created six maps with six combinations of the data discussed. We mapped crop production and pesticide and fertilizer use, irrigation and total cropped area.



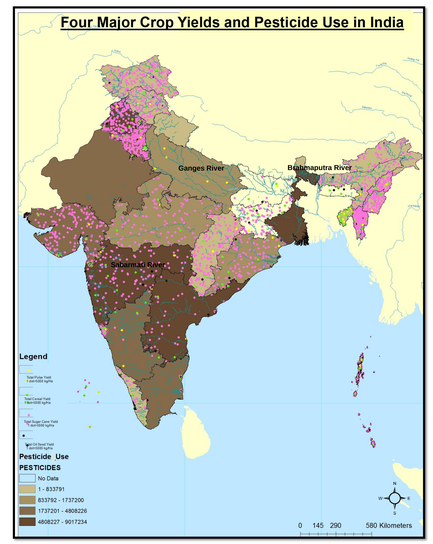
This map shows the total livestock in each state, including cattle, buffaloes, pigs, sheep, camels and donkeys, goats, and total area treated by fertilizers in hectares. Fertilizer use and quantity of livestock are positively correlated.



This map shows the total area treated by fertilizers in ha and four major crop yields, including pulses, cereals, sugarcane, and oil seeds. States that use greater amounts of fertilizer tend to grow greater quantities of these crops, especially sugar cane.



This map shows total livestock use and total area treated by pesticides in hectares. States that have greater amounts of livestock tend to use large amounts of pesticide, often for food sources for the livestock.



This map shows the top four major crop yields and total area treated by pesticides in hectares. States with higher concentrations of crops tend to have widespread use of pesticides.

Table 4 : Water Quality in Indian Rivers - 2002

River Name	Length (km)	No. of Monitoring locations	Observed Range of Water Quality Parameters							
			Temperature °C	pH	Conductivity (µmhos/cm)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Total Coliform (MPN/100 ml)	Faecal Coliform (MPN/100 ml)
Ganga	2525	34	3-34	6.4-9.0	19-2720	2.7-11.5	0.5 – 16.8	1-30	300-25x10^5	20-11x10^5
Yamuna	1376	23	3-34	6.7-9.8	56-1959	0.1-22.7	1.0 – 36	1-112	27-26.3x10^6	11-17.2x10^5
Sabarmati	371	8	12-32	2.9-8.6	269-13530	0.6-7.9	0.8 – 475	4-1794	210-28x10^5	28-28x10^5
Mahi	583	7	19-34	7.1-9.2	175-5720	0.2-8.5	0.1 – 3.0	9-163	3-2400	3-75
Tapi	724	10	20-40	7.4-9.0	76-700	4.8-8.8	0.6 – 10.0	8-40	40-2100	2-210
Narmada	1312	14		6.9-9.3	102-1341	5.8-9.8	0.1 – 3.8	6-47	9-2400	2-64
Godavari	1465	11	22-35	7.0-9.0	118-1400	3.1-10.9	0.5 – 78.0	3-96	8-5260	2-3640
Krishna	1401	17	18-33	6.8-9.5	28-11050	2.9-10.9	0.2 – 10.0	3-88	17-33300	3-10000
Cauvery	800	20	21-37	2.0-9.2	31-53100	0.1-12.6	0.1 – 26.6	30	39-160000	2-28000
Mahanadi	851	16	18-38	7.3-8.9	114-15940	1.3-10.4	1.0 – 7.6	7-39	15-30000	50-17000
Brahmani	799	11	20-38	7.0-8.4	81-376	5.2-9.8	1.5 – 6.0	8-13	80-90000	40-60000
Baitarni		5	24-36	7.3-8.3	54-78400	6.8-9.3	2.0 – 6.8	7	900-22000	700-11000
Subarnrekha	395	6	18-36	6.5-8.0	113-355	5.2-8.5	0.2 – 12.0	4-96	150-1800	70-540
Brahmaputra	916	6	15-32	6.5-9.0	104-684	1.1-10.5	0.1 – 3.9	6-11	360-240000	300-24000
Pennar	597	4	-	7.5-8.7	364-978	6.0-9.3	1.0 – 2.9	14-16	-	-
Sathuj	1078	20	9-32	6.8-8.8	131-819	3.8-11.4	0.1 – 45.0	1-80	8-35000	2-3500
Beas	460	19	3-32	7.1-8.7	53-517	5.2-11.5	0.3 – 5.0	1-13	2-2400	2-1600

This table shows several abiotic factors associated with water quality. The Ganga and Sabarmati River systems, mapped above, have poor water quality as seen in low DO levels, high BOD, and high total coliform. The Brahmaputra has relatively normal levels of water quality indicators.
Source: http://unstats.un.org/unsd/environment/envpdf/pap_wasess5a2india.pdf
IWG-Env, International Work Session on Water Statistics, Vienna, June 20-22 2005

Results

The map portraying the relationship between total amount of livestock and total fertilizer use showed that Daman and Diu have the smallest total amount of livestock, at 9,504, including sheep, goats, horses, pigs, buffaloes, and cattle. Uttar Pradesh had the greatest amount of total livestock: 103,810,034. Nagaland has 1871 hectares of area treated by fertilizer, including diammonium phosphate (DAP), Ammonium, Nitrogen, Phosphorous, and Potassium. The state with the lowest total area treated by fertilizer was again, Uttar Pradesh, with 24,329,469 hectares.

In the map showing pesticide use and crop yields, Daman and Diu had 348 hectares of land treated with pesticides, while Andhra Pradesh had 9,017,234 hectares of pesticide treated land. Mizoram, with the lowest total pulse yield, had 3.06 quintals/ha. The state with the most, Tripura, had 42.3 quintals/ha. The state with the lowest cereal yield was Uttar Pradesh and the lowest was Tripura, with yields of 2.17 quintals/ha and 73.5 quintals per hectare, respectively. Bihar had the lowest sugarcane yield, at 23.9 quintals/ha and Daman and Diu had the highest sugarcane yield at 2308.7 quintals/ha. The state with the lowest oil seed production was Daman and Diu, with 3.7 quintals/ha and the highest was Chandigarh with 21.6 quintals/ha.

In the proportional irrigation and cropped area map, we divided net irrigated area by total state area to create proportional data. The state with the lowest proportional irrigated area was Sikkim and the state with the highest proportional irrigated area was Haryana. For total cropped area, we also divided by total state area in order to receive a proportion. The state with the highest proportional cropped area was Punjab and the state with the lowest proportional cropped area was the Andaman and Nicobar Islands.

Discussion

Between all of the maps, we can conclude that there is a positive correlation between high levels of agriculture and high levels of potential point source pollution. These potential sources are cropped areas that utilize fertilizers and pesticides in states containing major waterways. States with higher levels of crop yields and greater amounts of livestock tend to use high amounts of either fertilizers or pesticides. With these proven correlations, we can analyze agricultural practices and their effects on the environment.

On our maps, we show that both the Ganges and the Sabarmati Rivers, located near areas of high agricultural production, with these unsustainable practices, do indeed have high levels of water contamination, including biochemical oxygen demand (BOD), extreme pH levels, and low amounts of dissolved oxygen (DO). We found that the Ganges and Sabarmati rivers, some of the most polluted river systems in India, are located in areas with high agricultural production, both livestock and crops, and heavy pesticide and fertilizer use. The Brahmaputra River serves as an example of a relatively healthy river which happens to run through states with low agricultural production such as Assam, Mizoram, and Manipur.

A potential effect of water contaminated by fertilizer byproduct, eutrophication, tends to result in algal blooms, which depletes the oxygen supply and hence the aquatic biodiversity. Runoff containing pesticides into water systems can cause health issues such as cancer and methamoglobinemia. Pesticides can also be found in the groundwater. The use of contaminated groundwater for irrigation results in contaminated crops, rendering negative health effects when ingested. Therefore there is a strong correlation between high levels of agriculture, resulting in water contamination, and both adverse environmental and health effects in India.