Environmental Policy, River Pollution, and Infant Health: Evidence from Kanpur, India

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The Basic Question

- How does environmental policy impact health in the developing world?

- Why does this matter?
  - Good policy is hard to come by
    - E.g., Greenstone and Hanna (2014)
  - Policy frequently faces opposition on economic grounds (jobs, wages)
  - Avoidance is an alternative strategy
    - E.g., Kremer, Leino, Miguel, and Zwane (2012)

  >> The mechanism matters

History has many examples of the health penalties of living in high pollution settings

- Alsan and Goldin (2015): the establishment of water and sewage systems in Massachussets can explain about 37 percent of the decline in mortality between 1880—1915

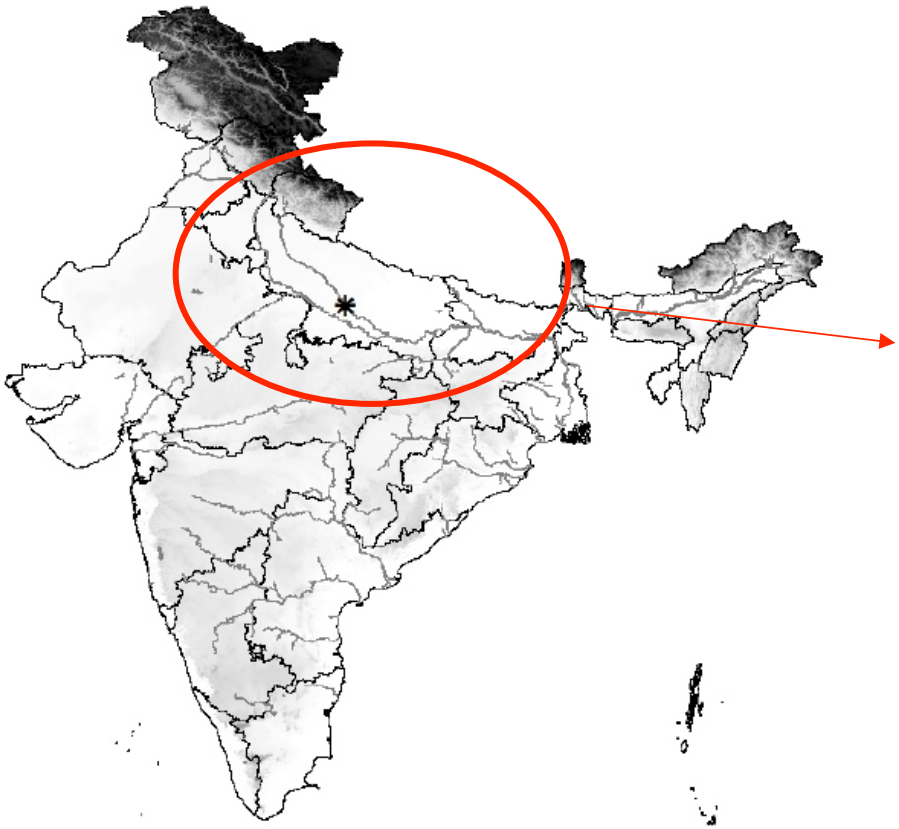
- Hanlon (2015): in 19th century England, industrial pollution explains about 33 percent of the mortality penalty of living close to factories

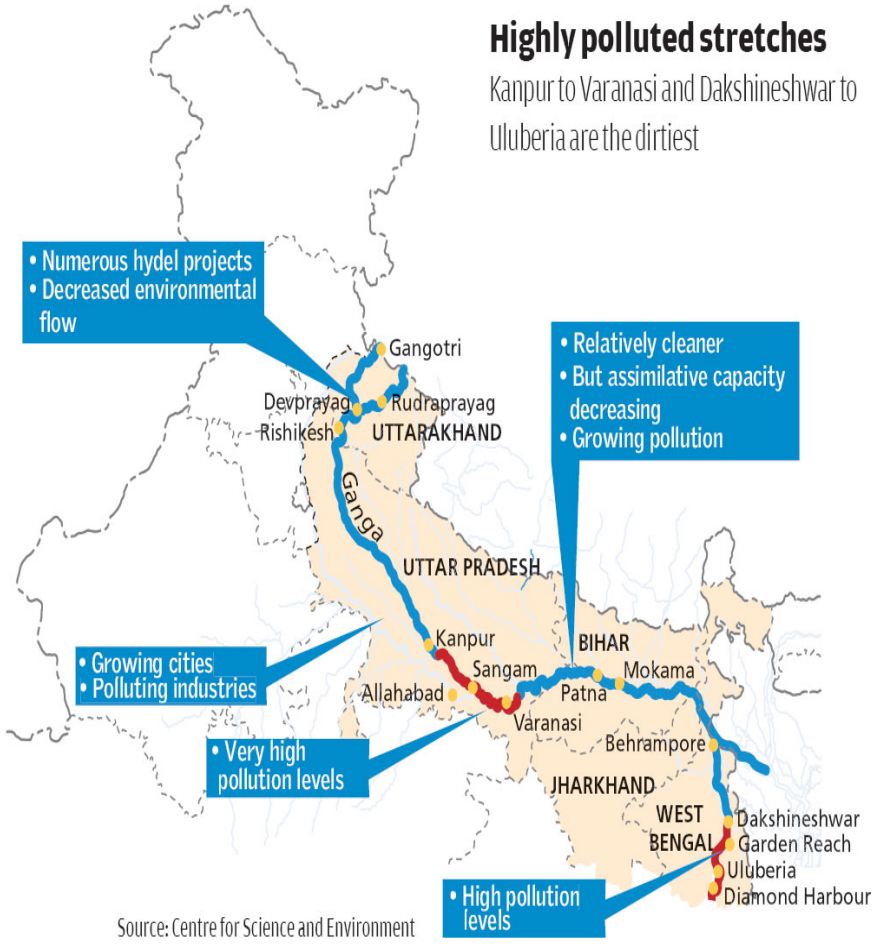
Overview of this paper

- We evaluate the impact of a policy that targets industrial water pollution in Kanpur, India
  - Policy: Unprecedented judicial verdict that mandates new treatment plants, plans for pollution control and major information campaigns
  - Estimate impacts on pollution and infant mortality

- We test whether the pollution channel explains the full impact of the policy on infant mortality
  - Pollution is not the only mechanism
  - Income, education and behavior modification are also plausible

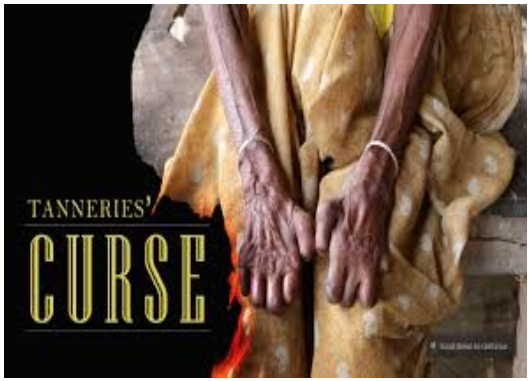
Location of our study





The tannery industry

- Most tanneries do the following:
  - Washing -> Liming -> Fleshing -> Tanning -> Splitting -> Finishing
- Highly polluting:
  - More than 175 polluting
  - Many chemicals highly toxic, carcinogenic and known to cause birth defects
  - Large disease burden
- In India, highly concentrated around three cities: Kolkata, Chennai and Kanpur
  - Kanpur is on the banks of the Ganges in the plains of India
  - For more than 100 years, Kanpur has been the “leather capital” of India



We study the first ever public interest litigation

- M.C. Mehta v. Union of India, Writ Petition No. 3727, filed in 1985 against tannery owners and the Kanpur municipalities for failing to keep the river clean:
  - Supreme Court of India ruled in his favor in October 1987
    - Tanneries ordered to either set up "primary treatment plants as approved by the State Board with effect from Oct 1, 1987" or "stop business entirely"
    - Municipality required to clean sewers, expand the sewage system and treat waste
    - Ban on placing dead bodies into the river

- The policy is quasi-random wrt both pollution and mortality
  - Mr. Mehta had no connections with Kanpur
  - Selection was random

Skipping the theoretical model for now... We estimate three equations

1. Mortality on Kanpur Regulation ("Mortality DD")

$$Mortality_{idt} = \alpha_0 + \alpha_1 Policy_{dt} + \alpha_2 Poll_{dt} \times US + \alpha_3 X_{dt} + \eta_{idt}$$

2. Pollution on Kanpur Regulation ("Pollution DD")

$$Poll_{dt} = \beta_0 + \beta_1 Policy_{dt} + \beta_2 Poll_{dt} \times US + \beta_3 X_{dt} + \varepsilon_{idt}$$

3. Mortality on Pollution ("River IV")

$$Mortality_{idt} = \theta_0 + \theta_1 Poll_{dt} + \theta_2 Policy_{it} + \theta_3 X_{dt} + \mu_{\blacksquare idt}$$

We use over-identification tests as mechanisms tests

- If the impact is only through pollution: *Policy* ➔ *Pollution* ➔ *Mortality*
- Then

  reduced-form impact *(Policy* ➔ *Mortality)*

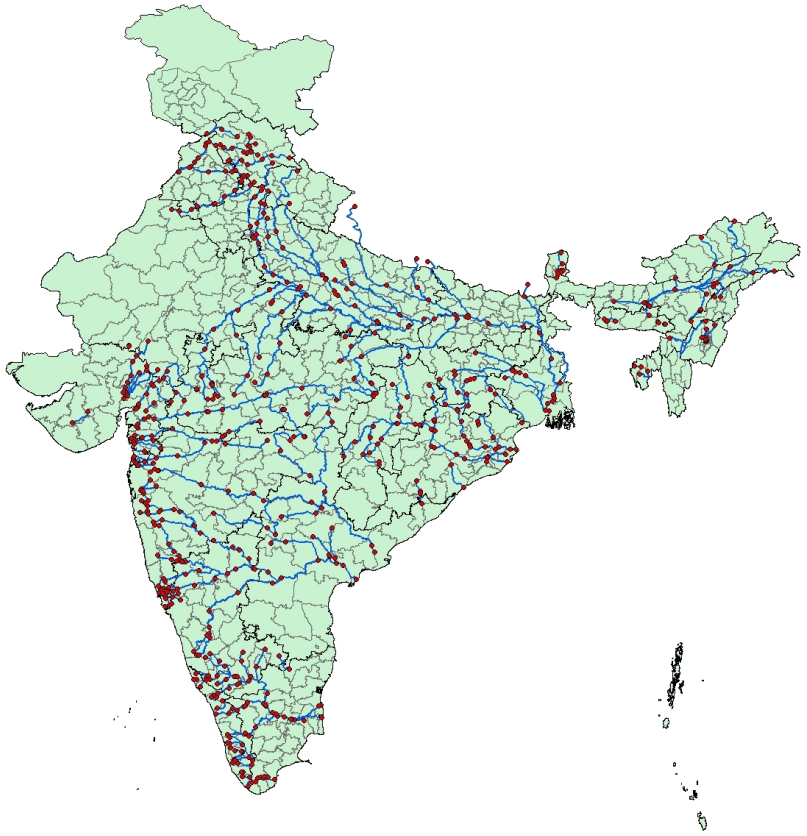
  = reduced-form impact (*Policy* ➔ *Pollution)*

  * reduced-form impact (*Pollution* ➔ *Mortality)*

- This is equivalent to testing that $Policy_{it-1}$ is a valid instrument for *Pollution*.
- We thus estimate 2SLS regression models using (a) upstream pollution alone as an instrument; and (b) upstream pollution and the policy, *BOTH* as instruments
  - A Hansen (or Sargan) J-statistic assesses overidentifcation

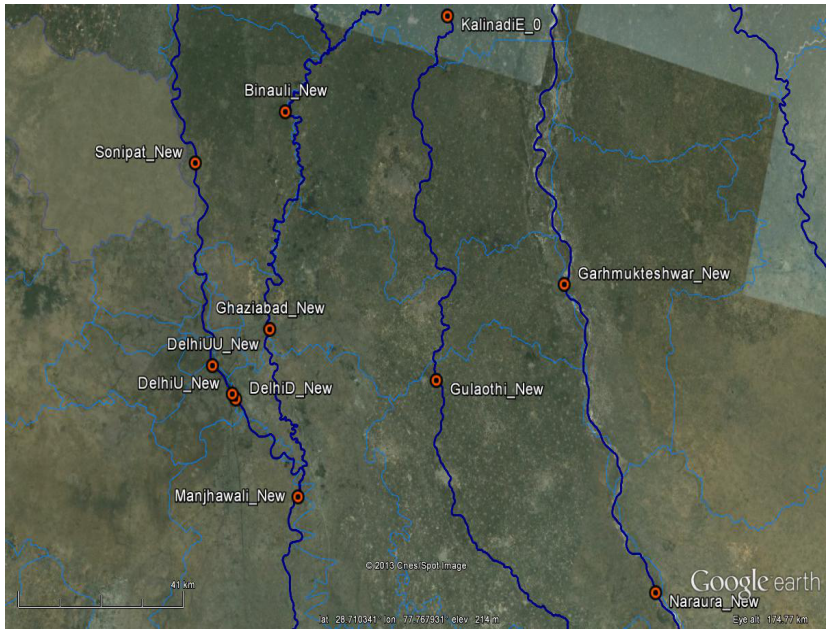
Data

- Water pollution: Monitor-months from 1986-2004 (CPCB)
  - 470 monitors along 162 rivers → 38,789 observations
  - Latitude and longitude of monitors
  - We focus mainly on BOD
- Infant mortality: Two different samples child-months
  - DLHS-II, RCH: 264,375 births → 2.6 million observations
  - Children only identified by district, NOT town village
- Policy:
  - Kanpur verdict (Oct 1987)



We construct a measure of upstream pollution using the geography of river flow

- Assign to every monitor an upstream counterpart
  - Identify the river on which the monitor resides
  - Follow that river upstream until it enters a new district
  - Find the next monitor upstream:
    - If its distance from the original monitor falls within [X,Y], assign it as the upstream monitor
    - If not, continue upstream until a monitor is found within [X,Y]
    - If no monitor is found within [X,Y], drop that monitor from the sample
    - If a river splits (due to the joining of a tributary), take the average of upstream monitors
  - X in {0, 20, 50, 75, 100}
  - Y in {200, 300}



Econometric details

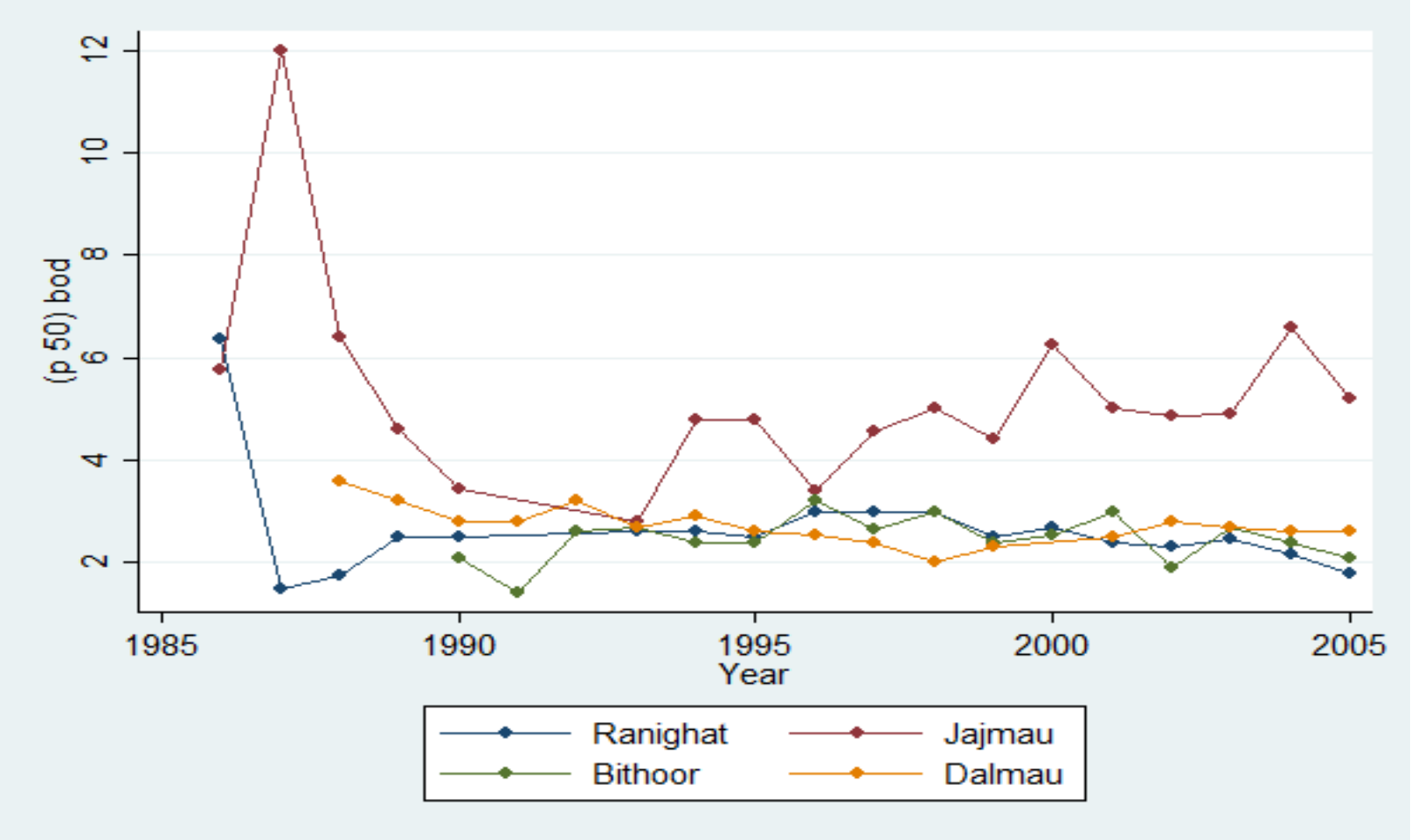
- Controls: air temperature, rainfall, distance upstream, incidence of the National River Conservation Plan, Common Effluent treatment plant capacity
- Policy impacts:

$$Y_{it} = a + \boldsymbol{b} Policy_{it} + dX_{it} + \varphi_{it} + \lambda_t + e_{it}$$

Y_{it} is either infant mortality or pollution

- Mechanisms: instrumental variables
  - Pollution is the endogenous variable
  - Upstream pollution and policy are instruments

A first glance…



Another simple look…

	Before the Verdict					After the Verdict					Difference
		Kanpur		Rest of the Ganga Basin	Difference		Kanpur		Rest of the Ganga Basin		
Child died within the first month of birth	136	0.110	1836	0.0719	0.0384 (0.100)	1478	0.0568	487064	0.0554	0.00138 (0.819)	-0.037* (0.019)
Child died within the first year of birth	1302	0.154	19337	0.103	0.0502 (0.0879)	17222	0.0662	487064	0.0723	-0.00610 (0.353)	-0.006* (0.003)
Female	1302	0.471	19337	0.474	-0.00273 (0.848)	17222	0.484	487064	0.480	0.00393 (0.310)	0.007 (0.015)

Reduced form regressions show policy reduces mortality

Table 2: Mehta vs. Union of India and infant mortality: reduced-form results

	Dependent variable: Child died in first month of life (1:yes;0:no)				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Child was born in Kanpur after 1987	-0.032**	-0.037**	-0.031**	-0.042***	-0.039**
	(0.011)	(0.011)	(0.010)	(0.005)	(0.014)
Child was born in a district downstream of Kanpur after 1987					-0.012 (0.017)
Time coverage	1986-2005	1986-2000	1986-1995	1986-2005	1986-2005
Geographic coverage	Ganga basin only	Ganga basin only	Ganga basin only	All India	Ganga basin only
R-Squared	0.012	0.013	0.018	0.009	0.012
N	45183	30387	13518	183325	45183

Notes: All regressions include set of controls (CETP capacity, air temperature, total precipitation, and NRCP dummy), of district fixed-effects and month-year fixed effects. Standard errors clustered at the district level in parentheses. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent, respectively.

Policy also lowers industrial pollution

Table 3: Mehta vs. Union of India and its impact on river pollution

	Dependent variable: pollutant							
	BOD	BOD	BOD	BOD	BOD	Fecal coliforms	Calcium	Sulphur
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Kanpur district after 1987	-0.431***	-0.477***	-0.559***	-0.438***	-0.216***	0.041	-0.116*	-0.679***
	(0.053)	(0.049)	(0.082)	(0.041)	(0.054)	(0.132)	(0.050)	(0.070)
District is downstream of Kanpur and after 1987					0.293***			
					(0.057)			
Time coverage	1986-2005	1986-2000	1986-1995			1986-2005		
Geographic coverage	Ganga basin only			All India		Ganga basin only		
R-Squared	0.706	0.689	0.732	0.593	0.710	0.593	0.614	0.405
Number of observations	2953	1755	997	15784	2953	2519	2224	2156

Notes: All regressions include set of controls (CETP capacity, air temperature, total precipitation, and NRCP dummy), of district fixed-effects and month-year fixed effects. Standard errors clustered at the district level in parentheses. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent, respectively. In columns (1)-(5), the dependent variable is whether BOD levels are above 3, in column (6), the dependent variable is whether fecal coliforms exceed cutoff of 5,000, and in columns (7) and (8), the dependent variable is whether levels of calcium or sulphur are above the sample median.

In the IV regressions, we find a positive relationship between pollution and mortality

Table 4: Mehta vs. Union of India and infant mortality: channels of impact

	Dependent variable: Child died in first month of life (1:yes;0:no)						
	OLS	**2SLS: 1 instrument**			**2SLS: 2 instruments**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BOD > 3 (1:yes,0:no)	0.004	0.090*	0.172*	0.186*	0.094***	0.112**	0.106***
	(0.004)	(0.043)	(0.085)	(0.081)	(0.021)	(0.042)	(0.031)
Child was born in Kanpur	-0.036**	-0.002	0.036	0.071			
after 1987 (1:yes;0:no)	(0.011)	(0.022)	(0.041)	(0.053)			
Geographic coverage			Ganga basin only				
Sample period	1986-2005	1986-2005	1986-2000	1986-1995	1986-2005	1986-2000	1986-1996
J-statistic (P-value)					0.929	0.343	0.213
R-Squared	0.013						
Number of observations	45183	45183	30387	13518	45183	30387	13518

Notes: All regressions include set of controls (CETP capacity, air temperature, total precipitation, and NRCP dummy), of district fixed-effects and month-year fixed effects. Standard errors clustered at the district level in parentheses. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent, respectively. Columns (2)-(5) show second-stage results of 2SLS

Mechanisms

- Hypothesis testing gives us a “failure to reject”, which suggests that the policy has likely affected mortality only through pollution

- Other factors have had a small effect (upper bound TBA)

Conclusions

- Identified impact of environmental policy regulation

- Assessed quantitative importance of one mechanism: lower reduction as opposed to avoidance

Extra Slides

Summary stats of key variables

	All districts					Kanpur District				
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
(A) RCH Data – averaged at the district level										
Died within 1 month	142248	0.053	0.107	0	1	498	0.085	0.121	0	1
Died within 1 year	141336	0.080	0.138	0	1	496	0.127	0.158	0	1
Female literacy	142247	0.431	0.285	0	1	498	0.388	0.241	0	1
Hindu	142248	0.757	0.299	0	1	498	0.824	0.191	0	1
SC	142183	0.183	0.195	0	1	498	0.272	0.193	0	1
ST	142183	0.162	0.281	0	1	498	0.006	0.029	0	0
Piped water	142248	0.418	0.332	0	1	498	0.163	0.174	0	1
Wealth Index	142248	-0.065	0.593	-1.080	2.978	498	-0.088	0.575	-1	3
Rural	142248	0.688	0.251	0	1	498	0.470	0.322	0	1
After verdict	142248	0.683	0.465	0	1	498	0.683	0.466	0	1
(B) Pollution data – averaged at the district level										
bod	22792	3.858	7.716	0.1	105	155	3.887	2.256	1	14
cod	22792	24.723	27.461	0.2	346	155	15.993	5.801	4	42
calc	23597	74.077	71.558	1	940	176	78.625	40.263	22	216
fcoli	17065	17449.220	96847.580	1	2100000	109	196020.300	325526.100	3	2100000
totcoli	17065	46410.510	241296.500	1	6300000	109	510203.700	855120.100	230	4600000