Economics of Water Pollution

A Brief Bibliographical Survey

Prepared by: Anuradha Kafle

SANDEE Bibliography No. 9-05

Table of Content

Topics	Page
1. Economics of Water Pollution	1
2. Water Pollution and Health	4
3. Ground Water Pollution	8
4. Policy and Management Issues	11
5. General and Websites	14

Economics of Water Pollution

1. Ahmad, J., B. N. Golder, S. Misra, M. Jakariya et al. (2002), 'Willingness to pay for arsenic free 'safe' drinking water in Bangladesh', (Field note / Water and Sanitation Program), New Delhi, India : Water and Sanitation Program - South Asia 16 p.

   Content**:** Brief description of a study on willingness to pay for arsenic-free, safe drinking water in rural Bangladesh which investigated the factors that influence demand for arsenic-free, safe drinking water and examined preferences regarding household/community-based arsenic mitigation technologies. The focus of this report is on the design, particularly the methodology used for estimating willingness to pay (WTP).The estimates of WTP obtained are presented. Some key results of the field survey, together with the main findings and policy recommendations, have been published in a separate note entitled, 'Fighting arsenic, listening to rural communities : findings from a study on willingness to pay for arsenic-free, safe drinking water in rural Bangladesh'.

   Full text available online at: http://www.wsp.org/pdfs/sa_arsenic_method.pdf
   http://www.wsp.org/pdfs/sa_arsenic_learning.pdf

2. Cao, H. and S. Ikeda (2005), 'Inter-zonal tradable discharge permit system to control water pollution in Tianjin, China', Environmental Science and Technology 39(13): 4692-4699.

   Abstract: In recent years, Chinese environmental authorities have expressed interest in the use of Tradable Discharge Permits (TDP) as a regulatory instrument to control pollutant emissions. Environmental professionals still have not had enough experience however, in designing and managing TDP systems, especially for non-uniformly dispersed pollutants. As an empirical study, this paper proposes an inter-zonal TDP system and analyzes its effectiveness in cost saving and environmental protection for reducing water pollutant COD (Chemical oxygen demand) in Tianjin, China. Zonal permit system (ZPS)

infections. The combination of excess illnesses associated with coastal water pollution resulted in a cumulative public health burden of $3.3 million per year for these two beaches. This paper introduces a public health cost variable that can be applied in cost-benefit analyses when evaluating pollution abatement strategies.

6. Diwakar, H. and N. Nagaraj (2002), 'Impact of water pollution on food security and environment: Bbearing the brunt', Wasteland News, August –October 2002.

7. Gunatilake, H. M., C. Gopalakrishnan and I. Chandrasena (2001), 'The economics of household demand for water: the case of Kandy Municipality, Sri Lanka', Water Resources Development 17(3): 277-288.

8. Harrington, W., A. Krupnick and W. Spofford (1989), 'The economic losses of a waterborne disease outbreak', Journal of Urban Economics 25: 116 - 137.

9. Hung, Ming-Feng and D. Shaw (2004), 'A trading-ration system for trading water pollution discharge permits', Journal of Environmental Economics and Management 49(1): 83-102.

Abstract: The fact that water flows to the lowest level uni-directionally is a very specific and useful property of water. By utilizing this property, we design a trading-ratio system (TRS) of tradable discharge permits for water pollution control. Such a trading-ratio system has three main characteristics: (1) the zonal effluent cap is set by taking into account the water pollutant loads transferred from the upstream zones; (2) the trading ratios are set equal to the exogenous transfer coefficients among zones; and (3) permits are freely tradable among dischargers according to the trading ratios. This paper shows that the TRS can take care of the location effect of a discharge and can achieve the predetermined standards of environmental quality at minimum aggregate abatement costs. Problems with hot spots and free riding can be avoided, and the burdens on both dischargers and the environmental authority should be relatively light.

10. Murty, M. N., A. J. James and S. Mishra (1999), 'Economics of water pollution: the Indian experience, xiii, 295 p, 0-19-564395-X, Oxford University Press, Delhi.

11. O'Shea, L. (2002), 'An economic approach to reducing water pollution: point and diffuse sources', Science of Total Environment 282-283: 49-64.

Abstract: A review of economic policy towards pollution control is presented which shows that appropriate measures will depend on whether the pollution is of a point or a diffuse nature. Regulation of the former is comparatively straightforward, with command and control and market instruments the tools of pollution control. The advantages and disadvantages of each measure are outlined. However, the inability to monitor emissions at source precludes the application of point source measures in the case of diffuse source pollution. Instead, methods are required which overcome the need for direct monitoring. Several suggestions that propose ways of achieving this have been put forward and these are described. It is concluded that appropriate measures depend on the particular features of the problem and it is not possible to offer a blanket solution to either point sources or diffuse pollution.

12. Paudel, K. P, H. Zapata and D. Susano (2005), 'An empirical test of environmental kuznets curve for water pollution', Environmental and Resource Economics 31(3): 325-348.

Abstract: The Environmental Kuznets Curve (EKC) on water pollution was investigated with both semi parametric and parametric models using watershed level data for the state of Louisiana, USA. The parametric model indicated the turning points within the range $10241-$12993, $6636-$13877, and $6467-$12758 for nitrogen (N), phosphorus (P), and dissolved oxygen (DO), respectively. However, only the parameters associated with N EKC were found to be significant. Model specification tests rejected parametric models in favor of semi parametric specification for P but not for N and DO.

13. Roy, J., S. Chattopadhyay, S. Mukherjee, M. Kanjilala, S. Samajpati and S. Roy (2003), 'An economic analysis of demand for water quality: A case from Kolkatta city', Economic and Political Weekly XXXIX (2): 186-192, January 10-16, 2004.

14. Sanchez-Choliz, J. and R. Duarte (2005), ‘Water pollution in the Spanish economy: analysis of sensitivity to production and environmental constraints’, Ecological Economics 53(3): 325-338.

Abstract: In this paper, we discuss the relationships between production processes and water pollution based on the recent Satellite Water Accounts (SWA) (INE (Spanish National Statistics Institute), 2002) and the 1997 input–output tables for the Spanish economy. The study focuses on four pollutants [biological oxygen demand (BOD), metals, nitrogen and phosphorus) and seven sector blocks. Firstly, we identify the roles of the various sector blocks as generators and consumers of each type of pollution. Secondly, we examine how pollution responds to changes in unit coefficients of pollution and final demand patterns to obtain the shadow prices for the different pollutants. The results obtained provide a sound basis for the design of improvements in environmental policy.

15. Yuting, G., C. Gangcai and C. Yongguan (2004), ‘The econometric assessment of losses by water pollution

<u>Water Pollution and Health</u>

18. Ahmad, S. A, M. H. Sayed, S. Barua, M. H. Khan, M. H. Faruquee, A. Jalil et al (2001), 'Arsenic in drinking water and pregnancy outcomes' , Environmental Health Perspective 109(6):29-31.

Abstract**:** We studied a group of women of reproductive age (15-49 years) who were chronically exposed to arsenic through drinking water to identify the pregnancy outcomes in terms of live birth, stillbirth, spontaneous abortion, and preterm birth. We compared pregnancy outcomes of exposed respondents with pregnancy outcomes of women of reproductive age (15-49 years) who were not exposed to arsenic-contaminated water. In a cross-sectional study, we matched the women in both exposed and nonexposed groups for age, socioeconomic status, education, and age at marriage. The total sample size was 192, with 96 women in each group (i.e., exposed and nonexposed). Of the respondents in the exposed group, 98% had been drinking water containing ≥0.10 mg/L arsenic and 43.8% had been drinking arsenic-contaminated water for 5-10 years. Skin manifestation due to chronic arsenic exposure was present in 22.9% of the respondents. Adverse pregnancy outcomes in terms of spontaneous abortion, stillbirth, and preterm birth rates were significantly higher in the exposed group than those in the nonexposed group ($p = 0.008$, $p = 0.046$, and $p = 0.018$, respectively).

19. Ahmad. S. K., D. Bandaranayke et al (1997), 'Arsenic contamination in ground water and arsenicosis in

unmetabolized As_i, monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA) excreted in urine within 24 h after the IV injection of 7.14 μg/kg AS_i. Liver disease does not affect the percent of the injected dose excreted within 24 h but has striking and opposite effects on the proportions of MMA and DMA. MMA excretion is highly correlated with the ^{14}C-aminopyrine breath test (r=0.73; P<0.05). The reduction in the proportion of MMA excreted in urine and the increase in that of DMA are similar with regard to sensitivity and specificity for detecting liver impairment. Unlike the ^{14}C-aminopyrine breath test, the inorganic arsenic methylation test offers the advantage of being unaffected by treatment with microsomal enzyme inducers.

27. Cebrian M. E., A. Albores, M. Aguilar and E. Blakely (1983), 'Chronic arsenic poisoning in the north of Mexico', Human Toxicology 2(1):121-133.

Summary: We compared the prevalence of signs and symptoms of chronic arsenic poisoning in two rural populations. The arsenic concentration in the drinking water of the exposed population was 0.41 mg/l, and 0.007 mg/l in the control population. The arsenic was present mainly (70%) in its pentavalent form. The objective was to quantitate health effects and risks derived from chronic ingestion of arsenic in contaminated water. In the exposed population, 21.6% of the sample, showed at least one of the cutaneous signs of chronic arsenic poisoning against 2.2% in the control town. Non-specific symptoms were more prevalent in the exposed population and they occurred more frequently in those individuals with skin signs. The relative risk of suffering a particular manifestation of poisoning, ranged from 1.9 to 36 times higher in the exposed population. We estimated the risks above mentioned, which were derived from exposure to minute quantities of arsenic in a known proportion of its oxidation states during a life time period.

28. Chakraborty, A.

Calderon and W. R Chappell, (eds.) Arsenic: exposure and health effects, London, Chapman and Hall, 112-123.

38. Guha, Mazumder D. N. , R. Haque, N. Ghosh et al (2000), 'Arsenic in drinking water and the prevalence of respiratory effects in West Bengal, India' , International Journal of Epidemiology 29:1047-1052.

39. Hertz-Picciotto I., H. M. Arrighi and S. W. Hu (2000), 'Does arsenic exposure increase the risk of circulatory disease?', American Journal Epidemiology 151:174-181.

40. Hsueh, Y. M., W. L. Wu, Y. L. Huang, H.Y. Chiou, C. H Tseng and C. J.Chen (1998), 'Low serum carotene level and increased risk of ischemic heart disease related to long-term arsenic exposure', Atherosclerosis 141:249-257. http://www.ec.gc.ca/water/en/manage/poll/e_poll.htm

41. Huet, P. M., E. Guillaume, J. Cote, A. Legare, P. Lavoie and A. Viallet (1975), 'Noncirrhotic presinusoidal portal hypertension associated with chronic arsenical intoxication', Gastroenterology 68:1270-1277.

42. Khan, A. W. et al (1997), 'Arsenic contamination in groundwater and its effect on human health with particular references to Bangladesh', Journal of Preventive and Social Medicine 16(1): 65-73.

43. Kurokawa, M., K. Ogata, M. Idemori, S. Tsumori, H. Miyaguni, S. Inoue et al (2001), 'Investigation of skin manifestations of arsenicism due to intake of arsenic-contaminated groundwater in residents of Samta, Jessore, Bangladesh', Archives of Dermatology 137:102-103.

44. Lai, M.S., Y. M. Hsueh, C.J. Chen, M.P. Shyu, S.Y. Chen

44. Lai, M.S., Y. M. Hsueh, C.J. Chen, M.P. Shy

hypopigmentation). Individual exposure assessment could only be estimated by present levels and in terms of a dose index, i.e., arsenic levels divided by individual body weight. Arsenic water concentrations ranged from 10 to 2,040 microg/L, and the crude overall prevalence rate for skin lesions was 29/100. After age adjustment to the world population the prevalence rate was 30. 1/100 and 26.5/100 for males and females, respectively. There was a significant trend for the prevalence rate both in relation to exposure levels and to dose index ($p < 0.05$), regardless of sex. This study shows a higher prevalence rate of arsenic skin lesions in males than females, with clear dose-response relationship. The overall high prevalence rate in the studied villages is an alarming sign of arsenic exposure and requires an urgent remedy.

53. Tseng, W. P., (1977), 'Effects and dose-response relationships of skin cancer and blackfoot disease with arsenic', Environment Health Perspective 19:109-119.

54. Valentine, J. L., H. K. Kang and G. Spivey (1979), 'Arsenic levels in human blood, urine and hair in response to exposure via drinking water', Environmental Science and Pollution Research 1: 24-32. 53.

Ground Water Pollution

57. Abdalla, C. W., B. A. Roach and D. J. Epp. (1992), 'Valuing environmental quality changes using averting expenditures: an application to groundwater contamination', Land Economics 68 (May):163-169.

Abstract: Water quality is a major environmental issue. Pollution from nonpoint sources is the single largest remaining source of water quality impairments in the United States. Agriculture is a major source of several nonpoint-source pollutants, including nutrients, sediment, pesticides, and salts. Agricultural nonpoint pollution reduction policies can be designed to induce producers to change their production practices in ways that improve the environmental and related economic consequences of production. The information necessary to design economically efficient pollution control policies is almost always lacking. Instead, policies can be designed to achieve specific environmental or other similarly related goals at least cost, given transaction costs and any other political, legal, or informational constraints that may exist. This report outlines the economic characteristics of five instruments that can be used to reduce agricultural nonpoint source pollution (economic incentives, standards, education, liability, and research) and discusses empirical research related to the use of these instruments.

58. Ahmad, J., B. N. Goldar, S. Misra and M. Jakariya (2002), 'Fighting arsenic, listening to rural. communities: willingness to pay for arsenic-free, safe drinking water in Bangladesh', www.wsp.org/publications/sa_arsenic_learning.pdf

59. Ahmad K. (2001), 'Wide spread arsenic contamination in Bangladesh', Lancet 358:133.

60. Ammann, A. A., E. Hoehn and S. Koch (2003), 'Ground water pollution by roof runoff infiltration evidenced with multi-tracer experiments', Water Research 37(5): 1143-1154.

Abstract: The infiltration of urban roof runoff into well permeable subsurface material may have adverse effects on the ground water quality and endanger drinking water resources. Precipitation water from three different roofs of an industrial complex was channelled to a pit and infiltrated into a perialpine glaciofluvial gravel-and-sand aquifer. A shaft was constructed at the bottom of the pit and equipped with an array of TDR probes, lysimeters and suction cups that allowed measuring and sampling soil water at different depths. A fast infiltration flow was observed during natural rainfall events and during artificial infiltration experiments. For a better understanding of the behaviour of contaminants, experiments were conducted with cocktails of compounds of different reactivity (ammonium, strontium, atratone) and of non-reactive tracers (uranine, bromide, naphthionate), which represent different classes of pollutants. The experiment identified cation exchange reactions influencing the composition of the infiltrating water. These processes occurred under preferential flow conditions in macropores of the material. Measuring concentration changes under the controlled inflow of tracer experiments, the pollution potential was found to be high. Non-reactive tracers exhibited fast breakthrough and little sorption.

61. Central Ground Water Board (July 1999),' High incidence of arsenic in ground water in West Bengal', Ministry of Water Resources, Government of India.

62. Chakraborty, D., G. Samanta et al (1994), 'Arsenic in ground water in six districts of West Bengal, India: biggest arsenic calamity in the world', Analyst 119, 168-170.

63. Chakraborty, D., G. Samanta et al (1996), 'Arsenic in ground water in six districts of West Bengal, India: biggest arsenic calamity in the world', Environmental Geochemistry and Health 18, 5-15.

64. Chakraborty, D., S. C. Mukherjee, S. Pati, M. K. Sengupta, M. M. Rahman and U. K. Chowdhury (2003), 'Arsenic groundwater contamination in Middle Ganga Plain, Bihar, India: a future danger', Environmental Health Perspectives 111(9):1194-1201.

65. Chowdhury, U.K., B. K .Biswas, T. R. Chowdhury, G. Samanta, B. K. Mandal, C. Basu et al (2000),
'

Policy and Management Issues

79. Adenuga, A., K. Ogujiuba and F. Ohuche (2005), 'Sustainability of the environment and water pollution in Nigeria: problems, management and policy options', EconWPA Working Paper No. 0508009. Website: http://econwpa.wustl.edu:80/eps/othr/papers/0508/0508009.doc

Abstract: Severe environmental degradation appears to be threatening the long-term development prospects of countries all over the world, particularly the developing ones such as Nigeria. The paper review108

85. Cheng, H., Z. Yang and C.W. Chan (2003), ‘An expert system for decision support of municipal water pollution control’, Engineering Applications of Artificial Intelligence 16(2): 159-166.

Abstract: This study presents an expert system (ES) for assisting departments of environmental management in their efforts to improve water quality in a city. The ES was built based on the premise that municipal water quality is related not only to the environmental conditions of a city, but also to its economic and social systems. The system called WPC-ES can analyze relationships between industrial water pollution and economic activities of industrial enterprises of a city. The system includes a decision model at its core, which integrates another four closely related subsystems. As an application, use of the system by the environmental protection agency of a city in the Yellow River Basin of China is presented. The results showed that the system could provide better decision support for

permit requirement, and, more recently, to enforcement of a mandate to achieve water quality standards. This Article describes the evolution of federal water pollution control legislation in the United States. It focuses particularly on the 1972 statute prescribing feasibility-based controls for point sources and its 1977 modification, the increasing concern with toxic pollution in the 1980s, and recent litigation requiring total maximum daily loads for waters that fail to meet *water* quality standards. The Article then examines this description to evaluate the accomplishments and failures of each step in the legislative evolution, and to extract practical lessons so that future water pollution control legislation may be successful.

95. Nazarov, N., H. Cook and G. Woodgate (2004), ‘Water pollution in Ukraine: the search for possible solutions’, International Journal of Water Resources Development 20(2): 205-218.

Abstract: In Ukraine, average and maximum concentrations of certain pollutants in inland water bodies are unacceptably high, while the number of heavy pollution accidents (one- a284.1 States. It focu70.68 0 411295 Tcapa295 0

General and Websites

101. Barah, B.C., V. Sipahimalani and P. Dhar (1998), 'Urban water supply and sanitation', in U. Sankar and O.P. Mathur, eds., Economic Instruments for Environment Sustainability, New Delhi: National Institute of Public Finance and Policy.

102. Eaton A. D., L. S. Clesceri and A.E. Greenberg (1995), 'Standard methods for the examination of water and wastewater', 19th ed. American Public Health Association, Washington, DC.

103. Howarth, W. and D. McGillivray (2001), Water pollution and water quality law, Shaw & Sons, 2001, cxiii + 1212pp, ISBN 0-7219-1102-1.

104. Jalan, J., E. Somanathan and S. Choudhuri (2003), 'Awareness and the Demand for Environmental Quality: Drinking Water in Urban India', SANDEE Working Paper No. 3-03.

105. Jalan, J. and S. Choudhuri (2004), 'The importance of being informed: experimental evidence on the demand for environmental quality', SANDEE Working Paper No. 8-04.

106. Klaauw, V. D. B and L. Wang (2004), 'Child mortality in rural India', Policy Research Working Paper 3281, The World Bank, Environment Department.

107. Krantz, D. and B. Kifferstein, 'Water pollution and society'. http://www.umich.edu/~gs265/society/waterpollution.htm

108. National Research Council (1999), 'Arsenic in drinking water', National Academy Press, Washington D.C., pp. 84-131.

109. Poppe, W. and R. Hurst (1997), 'Water pollution', Water Quality International, pp. 39-43.

110. Reed, S. C., E. J. Middlebrooks and R.W. Crites (1987), ' Natural systems for waste management and treatment', McGraw-Hill, NY.

111. Richman, M. (1997), 'Water pollution', Wastewater 5(2):24-29.

112. Spellman, F. R. and N. E. Whiting (1999), Water pollution control technology concepts and applications, ISBN 0-86587-660-6, pp. 401.

113. Smith, A. et al (1998), 'Cancer risks from arsenic in drinking water-implications for drinking water standard', Arsenic Exposure and Health Effects, W.R Chappel, C.O Abernathy and R.L Calderon ed., Proceedings of the Third International Conference on Arsenic Exposure and Health Effects, San Diego, California, 12-15 July, 1998.

fully standardized and published in the form of the Czech branch technical norm of water management (TNV) in the year 2000.

115. Ribaudo, M. C., R. D. Horan and M. E. Smith (1999), 'Economics of water quality protection from nonpoint sources: theory and practice', Agricultural Economic Report No. AER782:120pp, Dec. 1999. http://www.ers.usda.gov/publications/aer782/aer782.pdf

116. Terry, L. A. (1996), ' Water pollution', Environmental Law Practice 4(1): 19-39.

117. Wang, H. (2005), 'Probe on controlling of water pollution and its relative problems', Journal of Natural Science of Hanan Normal University 28(1): 84-87.

Summary: This paper analyzed the state of water pollution in China, and several control measures are promoted. The importance of waste water recycling as the effective way to resolve the contradiction of limited water resource and growing demand is emphasized.

118. World Health Organization (1996), ' WHO guidelines for drinking-water quality', Vol. 2. 2d Ed. Geneva: World Health Organization 156-67. http://www.who.int/water_sanitation_health/dwq/guidelines/en/