AGRICULTURE'S IMPACT ON WATER RESOURCES IN EASTERN EUROPE: BULGARIA, HUNGARY, AND ROMANIA

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ABSTRACT

Irrigation and other agricultural practices have had a profound impact on the environment in Eastern and Central Europe. The focus here is on water resources, the impact of irrigation on the environment, and the impact of agriculture on surface water and groundwater. Main impacts have been:

- Environmental degradation resulting from irrigation's heavy reliance on energy for lifting and pressurizing the water; and
- Degradation of surface water and groundwater from various sources, including agriculture. Agriculture's impact derives primarily from feedlots and from non-point sources such as fertilizers and pesticides.

Increases in prices for fertilizers, pesticides, and energy will generally have positive impact upon water resource quality, and on the environment.

BACKGROUND ON THE IRRIGATION SECTORS

Countries in Eastern and Central Europe have large irrigation sectors (see Table 1). The command area in Romania compares in size to that in California; Bulgaria can irrigate an area similar to that in Colorado; the irrigation command in Hungary can be compared with that in Arizona. Unlike the situation in the western United States, Eastern European irrigation is largely supplemental. Sprinkler irrigation is the dominant mode of application.

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TABLE 1

IRRIGATION SECTORS IN BULGARIA, HUNGARY, AND ROMANIA

	BULGARIA	HUNGARY	ROMANIA
Cropped Area (ha)	4,600,000	4,700,000	10,000,000
Area Commanded by Facilities (ha)	1,200,000	400,000	3,200,000
Irrigated Area (ha)	930,000	290,000	2,500,000
Sprinkler Irrigation (%)	45	75	87
Average Head (m) (elevation + pressure + losses)	130	65	145

ENERGY DEPENDENCE

The irrigation sectors in Bulgaria and Romania are highly dependent on energy. Most water used for irrigated agriculture must be lifted several times before it can be applied to the land. Romania pumps 80 percent of its irrigation water from the Danube River; the water is lifted several times before it is in position to use in agriculture. Bulgaria obtains about 20 percent of its irrigation water from the Danube, again through a series of lifts. Other smaller rivers supply water for irrigation, but this also must be lifted into offstream storage reservoirs (there are over 800 in Bulgaria) prior to application. This is quite unlike the situation in Northern California, where water is stored in the mountains and flows by gravity to irrigate lands below.

Eighty-seven percent of Romania's irrigated area is irrigated by sprinklers. In Bulgaria, about 0.5 million hectares — 45 percent of the irrigated area — rely on sprinkler irrigation. Sprinkler methods typically require pressurization equivalent to 35 meters of head for successful on-farm application.

The electromechanical systems (pumps and motors) used are notoriously inefficient. Romanian authorities estimate electromechanical efficiency at 59 percent. Breakdowns are frequent. Leakage is common, and much water must be repumped. Hydraulic efficiency was estimated by Romanian authorities at 40-70 percent, which may not be much different from systems in other countries.

The combination of lifting and pressurization results in an average energy expenditure for the country estimated at 130 meters by Bulgarian Ministry officials. Irrigation consumes 14 percent of all energy used by the agricultural sector.[2]

Romanian authorities have estimated energy expenditures for irrigation at 145 meters.[3] Assuming an average water application of 0.232 meters per hectare over 2.5 million hectares, a volume of 5,800 million cubic meters will be required. Power requirements are estimated at 3,900 million kilowatt-hours per year, or approximately 5.5 percent of Romania's electrical power consumption.[4]

If energy production leads to pollution problems — and it clearly does — then irrigation's demand for power in Bulgaria and Romania contributes to pollution. Eighty-two percent of Romania's electrical power comes from burning coal and hydrocarbons.[5] Power production that uses coal and hydrocarbons degrades the environment. Irrigation's dependence on energy in these two countries fuels this degradation.

Factors that contribute to huge energy expenditures should be examined in an effort to reduce energy dependence. There may be opportunity to reduce lifts if the governments adopt programs to support development of small-scale local water-supply sources (small streams, springs, and groundwater). These programs may favor land privatization and property downsizing. Because of scale considerations, little attention was devoted in the past to developing small-scale local sources.

Opportunities to reduce dependence on sprinkler irrigation would also reduce energy demands. If investments were made in land leveling, on-farm applications could be done by means of gravity. Micro-jet and drip irrigation are two other application

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[2] *World Energy Statistics and Balances*, 1985-1988 edition, International Energy Agency, Paris, 1990.

[3] Institute for Studies and Design of Land Reclamation Projects.

[4] Commission Report on Irrigation and Drainage, 1990-1991.

[5] Romanian Electricity Authority Report for 1990.

methods that consume less energy than sprinkler irrigation.

Energy efficiency can be improved by upgrading pumps and motors, replacing inefficient equipment, and investing in conveyance facilities to save water. A World Bank loan for Romania has been approved to fund an irrigation and drainage study establishing priorities for the subsector. The loan will enable the country to upgrade certain irrigation systems.

Based on prevailing energy prices in the world market, costs are about $0.30 per 1000 cubic meters per meter of head — or about $40 to lift and pressurize 1000 cubic meters (assuming combined energy requirements of 130 meters).[6] If a crop requires an irrigation application of 23 centimeters, the energy costs to supplementally irrigate one hectare are calculated at $92. Although these costs are not unusual by U.S. standards, agricultural users in Bulgaria currently pay a set fee of about $1.40 per hectare per year plus a volumetric charge of $0.11 per 1000 cubic meters, or about $1.65 to irrigate one hectare. Such pricing fails to recover power costs, let alone charges for maintenance or for recovery of capital costs.

The primary issue in irrigation is efficiency — not the common problem of efficiency of water delivery and conveyance loss, but rather efficiency of energy use. This is not an argument to levy higher water charges upon users; they simply will not be able to pay these higher charges. Rather, the case is made that Bulgarian and Romanian irrigation is inherently energy-intensive, and some person or some entity ultimately has to pay the bills.

SURFACE WATER POLLUTION

Throughout the region, water pollution is a major concern. The Romanian Ministry of the Environment estimates that, of wastewater returned to rivers and streams, only 10 percent is adequately treated, 60 percent is partially treated, and 30 percent is discharged without treatment. According to Ministry sampling of monitored river lengths, 39 percent falls

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[6] Converted from figures provided in Keller, Jack, and Ron Bliesner, *Sprinkle and Trickle Irrigation*, Van Nostrand Reinhold, 1990, p. 18.

nto the top category of water suitable for drinking ith only minor treatment, 30 percent falls into a ategory requiring moderate treatment, 12 percent equires a high degree of treatment, and 18 percent is nfit for most uses.

ndustrial and Urban Wastes

ontamination from toxic industrial wastes discharged o rivers is a high-priority concern throughout the egion. The principal contaminants are organic aterials, heavy metals, ammonia, and suspended solids. roblems are evident even to a casual observer: the requency with which industries discharge effluent to treams; color changes in rivers; and floating debris, ils, and foams. The World Bank, the European Bank for econstruction and Development, and others will provide upport to help countries clean up some of the most olluted rivers. One less-known but more insidious roblem is the discharge of radioactive leakage from ulgaria's nuclear power plant at Kozloduy into the rainage system of the Asparuhov Val irrigation system and from there into the Danube.

nother priority concern is the discharge of partially reated municipal sewage from large cities such as ucharest, Budapest, and Sofia, and from smaller cities s well. International funding has been targeted for onstruction of water treatment plants for Budapest and ucharest.

gricultural Pollution from Feedlots

griculture's contribution to surface water pollution as been less obvious, but substantial. Livestock eedlots are the principal agricultural source of urface water pollution. It is not coincidental that eedlots have been concentrated along major waterways ecause, typically, raw or partially treated effluent rom feedlots is discharged to rivers and streams.

n Bulgaria, 5,400 feedlots discharge an estimated 33 illion cubic meters of wastewater per year, creating a emand for water equivalent to 10 percent of municipal nd industrial water supplies for the country. Two-hirds of the feedlots do not meet environmental tandards. Most of the feedlots have experienced ecurrent problems with the treatment technologies they mploy and, at times, wastes cannot be treated or ontained.

In Romania, large livestock feedlots — each with more than 30,000 animals — discharge an estimated 125 million cubic meters of effluent per year, about the equivalent in volume to sewage effluent expected from a U.S. city with a population of one million. Swine wastewater has 3-4 times the Biologic Oxygen Demand (BOD_5) content of domestic wastewater. On a per capita basis, and allowing for average body weight, each pig produces about double the quantity of organic waste that a human produces.[7] If the amount of organic waste produced by the 7.2 million swine on large feedlots is compared with that produced by the city of Bucharest, we find that there is five times more organic pollution generated by swine feedlots than by Bucharest. It was estimated that less than five percent of the large swine complexes meet effluent standards (100 milligrams/liter) for BOD_5 discharge.[8] Also contained in the wastes are large quantities of suspended solids, nitrogen, phosphorus, potassium, and pathogens.

GROUNDWATER CONTAMINATION

Severity of the Nitrate Problem

Groundwater in Romania is heavily contaminated with nitrates. Shallow groundwater is unfit for drinking, exceeding the Romanian (and U.S.) standard — 10 parts per million of Nitrate-N or 45 parts per million of nitrates — in 40 percent of the cases. One survey, done in 1988 by the Institute of Public Health, covered 12,554 rural wells in 2,720 villages throughout the country. It showed 36 percent of the wells contaminated with nitrate concentrations exceeding the standard.[9] Nitrate concentrations were worst in irrigated agricultural areas of the country. A second

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[7] Pigs weighing 35 kilograms produce about 105 grams of BOD_5 per head per day; adult humans produce 54 grams of BOD_5 per capita per day. Source: Donald L. Day, *Report on Visit to Romania, May 26-June 6, 1975*, UNDP Report: Romania 3102, 1975.

[8] Environmental Research Engineering Institute, Bucharest.

[9] Cuca, M., Liliana Ursa, Ioana Iacob, and I. Petra, "Determination of Nitrate Levels in Groundwater in Rural Areas of Romania with an Appreciation of Public Health Aspects," *Caiet Metodologic I*, 1990.

rvey, by the Irrigation and Drainage Research stitute in 1991, reported on analyses of 850 oundwater samples from irrigation systems. Forty-one rcent of the samples contained Nitrate-N ncentrations in excess of 11.3 parts per million.

Bulgaria, the situation is similar. In three gions of the country, the ten-year average ncentration of Nitrate-N was 16 to 22 parts per llion. In these regions, it is estimated that 70-80 rcent of the population is exposed to drinking water at contains too much nitrate. In eight other regions the country, 35 to 45 percent of the population uses inking water with above-standard concentrations of trates. In the remaining eight regions of the untry, 2 to 30 percent of the population is similarly posed.

put the nitrate contamination problem into rspective, we can make comparisons with analyses rried out on groundwater in the United States. U.S. ologic Survey sampling of 124,000 wells over 25 years vealed that only 6.4 percent had Nitrate-N ncentrations in excess of 10 parts per million. An A survey, published in 1990, of 1,350 groundwater urces showed that only about two percent of the wells ceeded the standard.[10]

ur to five million Romanians rely on wells as their urce of drinking water. High concentrations of trates in drinking water can be fatal to babies under ree months of age. The Romanian Institute of Public alth estimates that each year 150-200 Romanian fants develop methemoglobinemia, or "blue-baby ndrome," which is caused by an excess of nitrates in inking water. Nitrate pollution is much more despread in Bulgaria and Romania than in Hungary. t, even in Hungary, dozens of cases of themoglobinemia, including some deaths, are reported ch year.

urces of and Solutions to the Problem

edlots, discussed above, are one likely main point urce for nitrogen in groundwater in Bulgaria and mania. Bulk handling of fertilizers may be another int-source contributant. Other non-agricultural

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[10] *Nitrate Occurrence in U.S. Waters*, USDA, shington D.C., September 1991, p. 2.

sources for nitrate contamination include human waste, vehicle discharge, and industrial pollutants.

Nitrates also enter groundwater from non-point sources such as nitrogenous fertilizers. In the centrally planned economies, the supply of fertilizer to state farms was closely geared to crop requirements.[11] However, because average yields were low — for example, Romania realized only 2.8 tons of maize per hectare and 3.2 tons of wheat per hectare — the crops failed to extract all the fertilizer that was applied, and a portion of the nitrogen ended up in the groundwater. In Romania, over the 11-year period from 1980 through 1990, it is estimated that 500,000 metric tons of nitrogen were applied in excess of crop requirements and were lost to ground and surface water. In Bulgaria, it was estimated that application of nitrogenous fertilizer exceeded uptake by 37 percent.

Groundwater Contamination from Organics and Heavy Metals

Data from Bulgaria and Romania show scattered evidence of organic and heavy metal contamination of groundwater. For example:

- Chlorinated hydrocarbon residues in groundwater tend to be in the nanogram range (10^{-9} grams per liter). This is considered an acceptable background level. Bulgaria banned use of chlorinated hydrocarbons in 1967; Romania banned their use in 1984.

- Organophosphates are sometimes — though rarely — reported in groundwater. Concentrations are very low — less than one microgram per liter. Where a problem exists, it has been associated with a specific point source of application.

- 2,4,D has been found in groundwater and surface waters at concentrations on the order of 10^{-8} to 10^{-7} grams per liter. Insofar as drinking water standards are concerned, Bulgaria does not permit any concentration of pesticides in water.

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[11] During the 1980s, the average amount of nitrogen applied through chemical fertilizers was 108, 120, and 75 kilograms per hectare in Bulgaria, Hungary, and Romania, respectively.

- Triazine, Atrazine, and Simazine have not been detected in Bulgarian groundwater, but in Romania, Triazine and Atrazine have been found in groundwater near the herbicide manufacturing plant at Pitesti.

- Lead and cadmium have been encountered in groundwater near Bulgarian chemical plants in Vratza, Smolen, and Mihailovgrad.

ı none of the countries is groundwater quality testing .despread nor is it done with regularity. Although :ganic compounds and heavy metals have been detected ı groundwater in Bulgaria and Romania, the Hungarian .nistry of Agriculture states that pesticide levels in :oundwater, soils, and plant material are far lower ıan limits set for health protection.[12] Against this ›ntention is the fact that pesticide use in Hungary — 7 kilograms of active ingredient per hectare per year is 40 percent higher than in Romania or Bulgaria. .ght-textured soils and intense agricultural activity ı central Hungary, between the Danube and Tisza .vers, make this area particularly vulnerable to :oundwater contamination.

NATIONAL AND INTERNATIONAL RESPONSES TO THE PROBLEMS

:rapped for funds, the Eastern European countries are ›t paying much attention to environmental concerns. ırthermore, the ministries of the environment in these ›untries tend to be newly established and therefore ;ak in comparison with the ministries of industry.

ıe European Community, the European Bank for ;construction and Development, and the World Bank are ıterested in making loans to countries in this region ›r environmental clean-up. The World Bank has :epared Environmental Sector Strategies for Bulgaria ıd Romania, and will make loans to these countries for ıvironmental programs. Priority concerns are nuclear ıfety and industrial clean-up. Relative to the urban ıd industrial sectors, agriculture is not a priority ›r environment-related funding.

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[12] Fesus, I., et al., *The Environmental Impacts of ;riculture in Hungary*, Ministry of Agriculture, ıdapest, 1991.

The U.S. government's response has been very weak. Numerous missions have occurred, yet few agricultural programs are in place. There has been intense rivalry between USDA and A.I.D. over which agency will represent the U.S. government in programs related to the agricultural sectors in the region. USDA is unable to think beyond a seminar circuit and a series of Best Management Practices demonstration plots; A.I.D. is more concerned with economic restructuring and privatization than with environmental issues. And with new funding demands for programs for the former Soviet Union, funding for agriculture/environmental programs in Eastern Europe was recently cut by 90 percent.

POLICY CONCERNS AND PRICES

Following their transition to market economies, all the Central and Eastern European countries instituted marked price increases for fertilizers and pesticides. As a result, use of nitrogenous fertilizers in Romania, decreased from 75 kg/ha during the 1980s to 15 kg/ha in 1991. Bulgaria and Hungary also cut back on fertilizer use, though not so dramatically. If nitrogenous fertilizer use remains low, this is likely to have a positive impact on nitrate levels in groundwaters.

However, the solution to the non-point source nitrate problem is not to cut back on fertilizers. Their rate of use in Bulgaria and particularly in Romania are already among the lowest in Europe. If yields can be increased, nutrient uptake will also increase and, with better production levels, an economic base will be in place to support environmental improvement. Cutting back on fertilizer inputs weakens the possibility for creation of an economic motor behind environmental improvement.

Best Management Practice Programs (of fertilizers) have been recommended by some as a way to address problems of nitrate contamination. Instead, the first priority should be directed to contamination generated by feedlots, for these represent a significant part of the problem — and dealing with point-source contamination will have a larger return in the short term.

Similarly, pesticide price increases have resulted in a decrease in pesticide use and a decreased probability of chemical residues in waters.

ergy price increases will have a positive impact upon
e environment. Highly subsidized energy prices
main a disincentive to increasing efficiencies in
rigation systems. Also, if the price was right,
rge livestock enterprises would be encouraged to
nvert current problems of livestock waste treatment
d disposal into opportunities for biogas and energy
oduction.