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Wildlife and the Coal Waste Policy Debate: Proposed Rules for Coal Waste Disposal Ignore Lessons from 45 Years of Wildlife Poisoning

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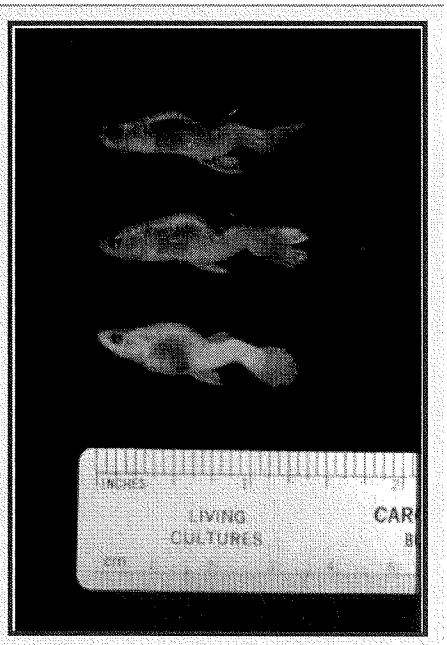
Supporting Information

ABSTRACT: This analysis examines wildlife poisoning from coal combustion waste (CCW) in the context of EPA's proposed policy that would allow continued use of surface impoundments as a disposal method. Data from 21 confirmed damage sites were evaluated, ranging from locations where historic poisoning has led to corrective actions that have greatly improved environmental conditions to those where contamination has just recently been discovered and the level of ecological impacts has yet to be determined. The combined direct and indirect cost of poisoned fish and wildlife exceeds $2.3 billion, which is enough money to construct 155 landfills with state-of-the-art composite liners and leachate collection systems. This cost is projected to increase by an additional $3.85 billion over the next 50 years, an amount that would construct 257 landfills. Evidence revealed through this study indicates the following: (1) for the past 45 years, environmental damage has been a recurring theme with surface impoundment of CCW, (2) the National Pollutant Discharge Elimination System has not been effective in preventing serious environmental damage from CCW, (3) EPA's Regulatory Impact Analysis of the costs and benefits of pollution control options fails to include benefits of avoided damages to natural resources, specifically, poisoned fish and wildlife, and (4) surface impoundments pose unacceptably high ecological risks regardless of location or design. Regulators should no longer ignore rigorous science and the lessons from multiple case examples. EPA and the United States need to show leadership on this issue by prohibiting surface impoundments, particularly since the rise in coal use in developing countries is leading to the same CCW pollution problems on a global scale.



INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is proposing the first national regulations for disposal of coal combustion waste (CCW).[1] The proposal has sparked debate among the electric utility industry, EPA, and the U.S. Office of Management and Budget (OMB) over certain provisions of the new rules, which will likely be finalized within the next year.[2] One key issue is whether to continue using surface impoundments as a disposal method. We conducted a comprehensive review of environmental damage cases and found that since 1967, surface-impounded CCW has caused major fish and wildlife losses and associated negative economic effects. EPA's Regulatory Impact Analysis,[3] which is a pivotal component of the joint EPA–OMB rulemaking process, fails to include damage to fish and wildlife in its cost-benefit evaluation. This oversight could have far-reaching consequences for natural resources in the U.S. and abroad, as both industrialized and developing countries are facing the same CCW disposal issues.

A LONG HISTORY OF DAMAGE AND ECONOMIC COSTS

The first widely recognized case of wildlife damage from CCW in the U.S. occurred in 1967 when a containment dam broke, spilling coal ash slurry into the Clinch River, VA, killing 217,000 fish and poisoning benthic invertebrates for 124 km downstream.[4] In 1976, releases from an ash pond permitted by the National Pollutant Discharge Elimination System (NPDES)

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caused a long-term, catastrophic toxic event at Belews Lake, NC, where selenium poisoning extirpated 19 species of fish from the 1560 ha reservoir (5, Figure 1). Belews Lake quickly became a landmark example of the ecological hazard of surface impounded CCW.

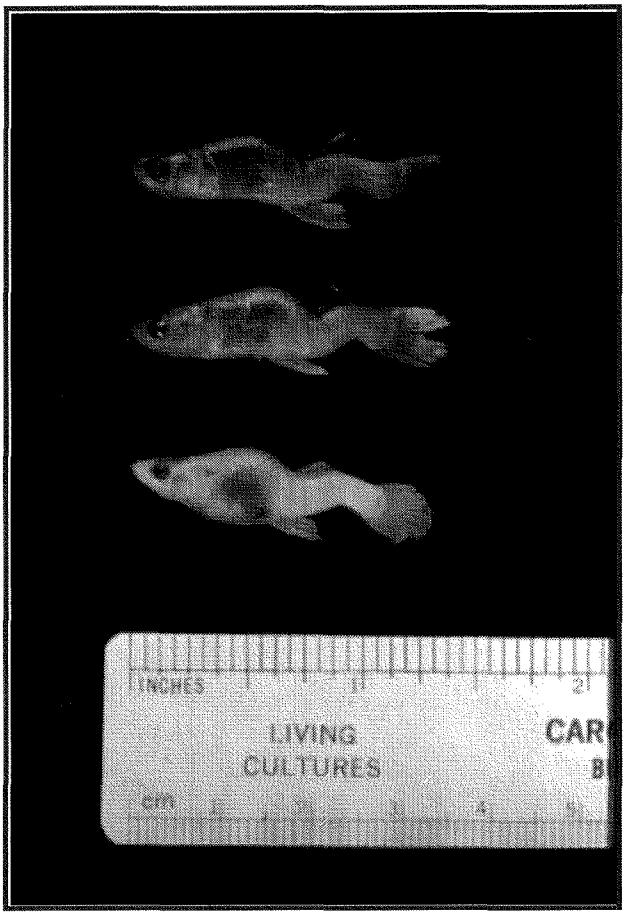

Figure 1. Toxic effects of coal combustion waste. Metals and trace elements leached from surface-impounded CCW have caused dramatic and costly impacts to aquatic life for decades. Effects range from acute mortality to chronic, debilitating toxicity as shown here in this 1980 photograph of fish from Belews Lake, NC, afflicted by selenium poisoning (v-shaped spines). Selenium bioaccumulates in food chains and passes from parents to offspring in eggs, where it causes a variety of skeletal deformities and other abnormalities in the developing embryos. This can lead to massive reproductive failure and local extinction of species (photo by A.D. Lemly).

Fish and wildlife damage cases continued to emerge throughout the 1980s and 1990s, affecting biota ranging from amphibians and fish to birds and reptiles, and causing impacts ranging from physiological, developmental, and behavioral toxicity to major population and community-level changes.[6] Perhaps the most dramatic example of pollution from wet disposal is the December 2008 spill at Tennessee Valley Authority's (TVA) Kingston Fossil Plant, TN, which released 4.1 million cubic meters of ash into the Emory River, inundating some 115 ha of aquatic communities and releasing over 3000 t of heavy metals and other contaminants to surface waters.[7,8] A similar but smaller disposal site collapse, this time spilling coal ash into Lake Michigan, occurred near Milwaukee at the We Energies Oak Creek Power Plant in October 2011.[9] A total of 21 surface impoundment damage cases have been documented (Supporting Information (SI), Table 1). Five of these resulted from structural failure of disposal ponds, two were caused by unpermitted discharge of ash pond effluent, two occurred at unregulated impoundments, and twelve, which includes the most costly cases, happened because of legally permitted releases allowed by the NPDES. The partially monetized direct cost of poisoned fish and wildlife coupled with the indirect human cost mediated by that poisoning was estimated to exceed $US 2.3 billion (see SI for methods used to calculate costs, Table 1).

Table 1. Summary of Fish and Wildlife Damage Cases from Disposal of Coal Combustion Waste

case	location	CCW disposal method	cause of water pollution	damage value ($US)
1	Belews Lake, NC	impoundment	NPDES permitted releases	531,153,873
2	Hyco Reservoir, NC	impoundment	NPDES permitted releases	864,742,344
3	Mayo Reservoir, NC	impoundment	NPDES permitted releases	80,825,500
4	Gavin, OH/ Amos, WV	impoundment	NPDES permitted releases	1,611,600
5	Martin Lake, TX	impoundment	unpermitted discharge	229,458,757
6	Welsh Reservoir, TX	impoundment	NPDES permitted releases	163,424,962
7	Brady Branch, TX	impoundment	NPDES permitted releases	108,674,277
8	Beaver Dam Creek, SC	Impoundment	NPDES permitted releases	17,979,360
9	Gibson Lake, IN	impoundment	unregulated discharge	166,425,914
10	McCoy Branch, TN	impoundment	unpermitted discharge	1,653,682
11	Clinch River, VA	impoundment	structural failure	11,377,700
12	Melton Hill Reservoir, TN	impoundment	NPDES permitted releases	40,598,560
13	Lake Erie, MI	impoundment	NPDES permitted releases	1,500,000
14	Connor Run, WV	impoundment	NPDES permitted releases	18,666
15	Euharlee Creek, GA	impoundment	structural failure	6,116,650
16	Bridger Plant, WY	impoundment	unregulated discharge	14,291,000
17	Delaware River, PA	impoundment	structural failure	31,445,100
18	Adair Run, VA	impoundment	NPDES permitted releases	160,000
19	Rocky Run Creek, WI	impoundment	NPDES permitted releases	240,000
20	Widows Creek, AL	impoundment	structural failure	3,862,300
21	Hatfield's Ferry, PA	landfill	NPDES limits exceeded	5,987,100
22	Kingston, TN	impoundment	structural failure	29,463,128
			total	2,311,010,473

WILDLIFE DAMAGE NOT CONSIDERED IN IMPACT ANALYSIS

OMB has statutory authority to examine a proposed EPA regulation, review economic information, and make a controlling decision on the final rule.[10] As part of this process EPA conducted a Regulatory Impact Analysis (RIA) for use in

comparing benefits and costs of the three options in its proposed rule (RCRA Subtitle C, regulation of CCW as hazardous waste with mandatory landfill disposal, no use of surface impoundments; Subtitle D, regulation as nonhazardous waste with use of lined surface impoundments; Subtitle D "Prime", continued use of existing unlined surface impoundments, liners required for those constructed in the future).[3,11] That analysis shows the annualized benefits of pollution control to be much greater for Subtitle C regulation than either Subtitle D option (Summary Exhibits 5–7 in ref 3). However, RIA only estimated benefits of avoiding human cancer deaths, groundwater pollution, and cleanup costs of impoundment dam failure.... "RIA did not quantify or monetize several other additional benefits consisting of future avoided social costs associated with ecological and socio-economic damages. These included avoided damages to natural resources".[3] In order for RIA to be thorough and complete, EPA needs to add the substantial economic benefit of avoiding damages to natural resources, specifically, poisoning of fish and wildlife. Based on the losses documented by scientific investigation since 1967 (SI, Table 1), protection of fish and wildlife through elimination of surface impoundments will add at least $76 million per year ($3.85 billion total cost savings spread across 50 year future period-of-analysis; Table 2) to the total annualized benefit value of regulation under RCRA Subtitle C. We used the 75th percentile annualized cost to project benefit values rather than the median because we know that our calculations are underestimates due to the fact that in most cases ecological impacts began well before scientific investigation and also extended longer than the actual period of investigation, sometimes for many years. Moreover, in most cases the investigations focused exclusively on fish, which means that the value of damage to other aquatic life and birds could not be included in cost estimates. Therefore, we believe that the 75th percentile is a reasonable and conservative number for use in projecting future cost savings. Placing the magnitude and importance of these cost savings in perspective, the total fish and wildlife protection value of $3.85 billion is greater than EPA's monetized value for human cancer risks avoided *plus* the groundwater protection value gained under Subtitle C, estimated for both a 3% and 7% discount rate ($970 million for 7% discount rate, $3.32 billion for 3% discount rate; Exhibit 5A-18, page 130 in ref 3). The benefit value for combined human and ecological protection under Subtitle C would therefore range from $4.82–7.17 billion, independent of the additional benefit value of preventing future impoundment dam structural failures (avoided cleanup costs) which adds another $1.76–7.40 billion (Exhibit 5B-6, page 141 in ref 3).

REGULATORY IMPLICATIONS

Surface impoundment of CCW is widely practiced, accounting for about 21% of current disposal facilities, or some 629 impoundments.[12] However, less than 5% of these have undergone detailed biological evaluation to determine impacts to fish and wildlife, usually following catastrophic failure of containment dams or because there was outwardly visible poisoning that triggered public demands for investigation. Therefore, our analysis (SI, Table 1) likely covers only a small portion of the total damage and economic costs resulting from this waste management technique. Yet, the value of that fraction of losses is conservatively estimated at over $US 2.3 billion, which is enough money to construct 155 landfills with state-of-the-art composite liners and leachate collection systems ($15 million each[13]). Our projected 50-year future damage cost of $3.85 billion would construct 257 such landfills. The Electric Power Research Institute, the scientific arm of the coal power industry, has known the inherent environmental hazards from

Table 2. Annualized Costs for 21 Environmental Damage Cases Resulting from Surface Impoundment of Coal Combustion Waste

year	total number of cases	total damage value ($US)
1967	2	5,252,260
1968	2	1,881,260
1969	2	1,806,260
1970	2	176,294
1971	2	176,294
1972	2	176,294
1973	4	802,232
1974	6	1,960,690
1975	6	1,960,690
1976	7	34,040,543
1977	7	34,040,543
1978	11	83,739,205
1979	11	83,739,205
1980	11	83,739,205
1981	11	88,580,947
1982	10	88,540,947
1983	10	88,540,947
1984	10	88,540,947
1985	10	88,540,947
1986	10	88,540,947
1987	11	76,610,198
1988	11	76,897,427
1989	11	76,971,752
1990	11	76,975,052
1991	10	76,861,977
1992	11	78,542,966
1993	11	72,520,501
1994	11	72,517,201
1995	11	72,467,201
1996	11	72,467,201
1997	12	76,011,984
1998	12	50,260,961
1999	12	50,360,961
2000	12	53,373,236
2001	13	49,337,586
2002	14	50,240,233
2003	12	47,131,908
2004	11	49,316,693
2005	13	65,468,599
2006	12	61,096,772
2007	9	53,267,156
2008	8	33,411,392
2009	8	28,394,018
2010	7	25,730,818
totals by decade		
1970s	11	240,811,933
1980s	11	845,504,270
1990s	12	698,986,009
2000s	14	491,037,599
median annualized cost		57,235,005
75th percentile annualized cost		76,974,227
90th percentile annualized cost		88,540,948
projected 50 year damage value using 75th percentile cost		3,848,711,350

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surface disposal of CCW for decades and has held workshops to inform the electric utility industry about those toxic threats.[14] Electric utilities themselves acknowledge the need to switch from wet to dry storage in order to protect shareholders from significant financial risks.[15] Yet, since 1967, little has changed from either an operational or regulatory perspective. Continued use of surface impoundments would be allowed by EPA under RCRA Subtitles D and D "Prime" of its proposed regulations for CCW disposal.[10] Evidence suggests this would be a grave mistake for seven reasons. First, the Subtitle D "Prime" option allows continued operation of existing unlined impoundments, which leads to substantial pollution of groundwater, some of which can be expected to reach the surface and expose fish and wildlife to toxicants.[16,17] Second, although provisions of Subtitle D do require the installation of composite liners, it should be noted that liners are designed to protect groundwater and would have little effect on the direct surface water exposure pathway.[11] That is, liners do not reduce above-ground leachate, precipitation runoff, and slurry discharges that pollute surface water and poison fish and wildlife. Third, there are serious liner performance issues (holes/tears created in geosynthetic membranes during installation, engineering/construction design standards that consider major leakage to be acceptable, physical/chemical breakdown of clay components over time) which indicate that groundwater protection is not assured.[18−20] Therefore, exposure of fish and wildlife to contaminated groundwater that reaches the surface is a distinct possibility even at lined sites. Fourth, surface impoundments are a particularly insidious threat to wildlife because of their ability to serve as attractive nuisances. Many animals, especially birds and amphibians, are drawn to these sites to feed and reproduce and as a result suffer exposure to trace elements and experience adverse health effects.[21] Fifth, the possibility of structural failure has not been given adequate consideration as a serious drawback of surface impoundments. For example, in the supporting material for its proposed rule, EPA states that "The more recently documented damage cases provide evidence that current management practices can pose additional risks that EPA had not previously studied, that is, from catastrophic releases due to the structural failure of CCR surface impoundments".[11] Sixth, a major flaw in the RCRA Subtitle D and D "Prime" options is that enforcement actions for violations would be possible only through citizen lawsuits; neither state nor federal government would be authorized to take direct regulatory action. RCRA Subtitle C regulation, however, would eliminate surface impoundments and authorize federal oversight to ensure that stringent national guidelines for landfill disposal of CCW were followed uniformly at the state level.[1,11] Seventh, and perhaps most importantly, current state-administered regulatory controls are ineffective in preventing discharge of toxic CCW effluent to surface waters. For example, NPDES, a federal-state regulatory mechanism for controlling point-source pollution, has been in place since the enactment of the federal Clean Water Act in 1972.[22] NPDES is the principal tool that states use to limit toxic industrial discharges.[23] However, it did not identify or correct any of the twelve surface impoundment regulated-release CCW damage cases reviewed in this report. This is because of lack of federal oversight combined with inadequate monitoring, risk assessment, and enforcement at the state level. EPA recognized these deficiencies in a recent study of steam-electric plant discharges[24] which concluded that:

> *"Despite current regulatory controls and wastewater treatment methods, pollutants from power plant wastewater still make their way into the environment. Many of these pollutants, such as selenium, arsenic, mercury, total dissolved solids, and nutrients, have an impact on wildlife. The primary routes by which coal combustion wastewater impacts the environment are through discharges to surface waters, leaching to ground water, and by surface impoundments and constructed wetlands acting as attractive nuisances that increase wildlife exposure to the pollutants contained in the systems. EPA found the interaction of coal combustion wastewaters with the environment has caused a wide range of environmental effects to aquatic life."*

The flawed NPDES regulatory system would not change if RCRA Subtitle D or D "Prime" were put in place.[1,11] The ecological need for this change has been expressed over and over in the form of toxicity to wildlife for the past 45 years, yet the system remains ineffective. For example, as of October 11, 2010, the new NPDES permit for the Kingston Fossil Plant (see SI, Case 22) did not contain effluent limits for 16 primary toxic elements, including arsenic, mercury, and selenium,[25] despite prior, persistent toxicity of discharges to fish and invertebrates in addition to the catastrophic ash spill that occurred in 2008. The NPDES permit for the period 2004−2008[26] stated that

> *"The discharge from Outfall 002 may contain several different pollutants, the combined effect of which has a reasonable potential to be detrimental to fish and aquatic life"..."As presented with the TVA's permit application, fish survival [1999−2003] has been problematic in Outfall 002 and the Emory and/or Clinch River".*

The permit was renewed in 2009, following the ash spill, without modification or establishment of discharge limits for the 16 primary toxic elements.

■ CONCLUSIONS

A large body of scientific evidence from confirmed damage cases indicates that wet disposal of CCW is not environmentally or economically prudent. EPA's regulatory proposal for CCW under RCRA Subtitles D and D "Prime", which would allow continued use of surface impoundments, is inappropriate with respect to fish and wildlife health. Moreover, going all the way back to the Belews Lake era of the 1970s, the corrective action at problematic surface sites has been to switch to landfill disposal.[27] In the wake of the catastrophic dam failure at Kingston, TN, the TVA has now decided to phase out all wet basins and use landfills as well.[28] This is an excellent example of the proactive measures that are needed in the post-Kingston era. Surface impoundment of CCW unnecessarily jeopardizes fish and wildlife populations, causes significant long-term environmental damage, and results in high economic costs that could be avoided or minimized if other disposal practices were used. The electric utility industry vigorously opposes RCRA Subtitle C regulation and it has enjoyed an open voice at the negotiating table, meeting with OMB some 20 times even before EPA issued its proposed rule.[2] Utility's opposition is founded in the contention that it would be unduly burdensome (costly) to the industry. Our commentary is a voice for fish and wildlife in the debate. We maintain that ignoring the past 45 years of wildlife poisoning and allowing it to continue is even more "unduly burdensome" to the environment and also unethical. The benefit value of avoided ecological damage is a significant cost savings that has not been included in the

discussion, but should be. Much of industry's regulatory "burden" cost claims are more than offset by prevented ecological damage and associated monetary losses. Regulators should no longer ignore rigorous science and the lessons from multiple case examples. EPA, OMB, and the United States need to show leadership on this issue by prohibiting surface impoundments, particularly since the rise in coal use in developing countries is leading to the same CCW pollution problems on a global scale.[29−31]

■ ASSOCIATED CONTENT

Supporting Information

Our comprehensive cost analysis of all 22 environmental damage cases, which formed the underlying technical basis for this report. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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The conclusions and recommendations in this report are those of the authors and do not constitute or imply an official policy position by the United States Forest Service or the United States Fish and Wildlife Service.

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EDITOR'S NOTE

Hard copies of documents from outdated Weblinks in the reference list are available from the corresponding author upon request.