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GEOGRAPHY | RESEARCH ARTICLE

Urban-rural waste borderlands: City planning, EU water quality, and local wastewater

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Abstract: Because EU water quality policy can result in infrastructure creation or adaptation at the local level across member states, compliance cases are worth examining critically from a sustainable spatial planning perspective. In this study, the 2000 EU Water Framework Directive's (WFD) reach to local implementation efforts in average towns and cities is shown through the case study of non-conforming household wastewater infrastructure in the German state of Rhineland-Palatinate. Seeing wastewater as a socio-technical infrastructure, we ask how the WFD implementation can be understood in the context of local infrastructure development, sustainability, and spatial planning concepts. In particular, this study examines what compliance meant for the centralization or decentralization of local wastewater infrastructure systems—and the sustainability implications for cities from those choices.

Subjects: Development Studies, Environment, Social Work, Urban Studies; Urban Studies; Built Environment; Planning and Sustainability; Rural Planning; Spatial and Regional Planning; City and Urban Planning; Rural Development; Geography; Planning - Human Geography

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PUBLIC INTEREST STATEMENT

The European Water Framework Directive 2000/60/EC (WFD) requires member nations to measurably achieve “good” water quality status across diverse water bodies including rivers, lakes, and groundwater. Compliance has thus affected a wide variety of planning processes and infrastructure systems, including wastewater. This study examined the infrastructure choices made by local communities in the German state of Rhineland-Palatinate, especially around the compliance of older septic systems. In many cases we found that the infrastructure added to comply with the WFD arguably detracts from sustainable wastewater planning in a larger sense, such as the need for more flexible, decentralized wastewater infrastructure.

1. Introduction

While water policy and the spatial planning of cities have always been intertwined in various ways, the EU Water Framework Directive's (WFD) call for the integration of water protection and land management has not been easy. In 2000, the European Union adopted the WFD, a milestone in enforceable environmental regulation across Europe. The primary goals of the directive include: expanding the scope of water protection to all waters (surface waters and groundwater), achieving not only a good chemical but also a good ecological quality for all waters, water management based on river basins, a greater organized public involvement, and streamlined legislation (European Commission, 2016a). As such, the WFD constituted a "new environmental governance" and an integrated environmental politics (Petersen & Klauer, 2012). It also marked a participation paradigm shift, requiring "a new style of decision-making in and beyond the water community which is more open, more consultative" (Moss, 2004, p. 89).

The WFD affects many types of water infrastructure, including local municipal wastewater systems. Research on local infrastructures has widely undergone a conceptual transformation over the last two decades from a technical focus to a sociotechnical one, meaning not only that a variety of social aspects are now taken into account but also notably that infrastructures co-evolve between society, nature, and technology (Edwards, 2004; McFarlane & Rutherford, 2008; Monstadt, 2009; Obertreis, Moss, Mollinga, & Bichsel, 2016). In particular, modern infrastructure ideals, such as networked infrastructure, have come under increasing scrutiny (Coutard & Rutherford, 2015). One subtopic of interest in socio-technical infrastructure research has involved the social, economic, and sustainability ramifications of centralized and decentralized water infrastructure. In addition to socio-technical interest in wastewater infrastructure research, we have also seen an expansion of new waste geographies (Moore, 2012).

In the instance of the WFD, the resulting impacts from the WFD (see timeline below in Figure 1) trickled down in large and small ways, even to the sanitary infrastructure of individual households. This linkage between European water protection policy, its local implementation and resulting infrastructure, and the creation of urban vs. rural space is illustrated through this study involving septic tanks in the German state of Rhineland-Palatinate.

Although most German cities have possessed extensive urban sewer networks and modern wastewater treatment plants for several decades, the outlying rural areas still naturally consist of a mixture of old and new, centralized and decentralized wastewater solutions. As such, these outlying areas represent something of a borderland, or perhaps a frontier, where notions of urban and rural waste are blurred. Viewing human waste as a manageable object, which is cultural in itself, opens it to a host of technical and institutional solutions (Moore, 2012, p. 786)—as well as different levels of governance.

Already in the early 1990s, predecessor policies to the WFD laid the foundation in the area of wastewater management in Europe, such as the Directive 91/271/EEC on Urban Waste Water Treatment (for a chronology of European water legislation see Kaika, 2003, p. 301). As with previous directives, the WFD had to be first adopted into respective national legal frameworks, which took place during the first timeline segment up until 2009. This initial transposition of the WFD into national contexts also could have marked the first deviance from its "big picture" systemic goals (Voulvoulis, Arpon, & Giakoumis, 2017, p. 361).

Figure 1. The 2000 EU Water Framework Directive implementation timeline.

Source: Umweltbundesamt (Federal Environment Agency), 2016, p. 8



In Germany, the federal and state government agencies must work together along with river basin districts and other actors to cooperatively implement the WFD (Umweltbundesamt 2016, p. 12). Relevant for our study were the wastewater aspects adopted into a few key federal laws. The Wasserhaushaltsgesetz (The Federal Water Act) specifies in §57, for example, that only waste treated up to technical standards may enter ground and surface waters. More specific technical requirements for the release of wastewater are set out in the Abwasserverordnung (Federal Waste Water Ordinance), and the Abwasserabgabengesetz (Waste Water Levy Act) addresses the fiscal aspects for the release of wastewater. Such federal laws are then further incorporated into state laws, which may include additional state or regional-specific provisions (Umweltbundesamt, 2001, p. 12). Ultimately, municipalities then have the duty of organizing water and wastewater supply for residents.

Cutting across hierarchies, WFD implementation revolves around the development of river basin management plans (Bewirtschaftungsplan). In Rhineland-Palatinate, the state also produced extensive documentation and events synthesizing their role in WFD implementation in several river management plans.

Given the new technical requirements and governance ramifications that trickled down from the WFD, it is useful to next consider the closely-aligned processes of spatial planning in towns and cities. The WFD acknowledges water as a resource beyond traditional administrative and political boundaries, yet these are precisely the layers within which spatial planning operates (Carter, 2007, p. 340). Spatial planning can: consider water supply and infrastructure necessary to support development, minimize the risk from water-related disasters, and help realize environmental protection goals (Carter, 2007). Local efforts to conform with heightened water protection requirements necessarily transgress intra-municipal building and land use spatial categories, such as the interior and exterior areas for building.

Spatial planning and building categorizations in Germany, such as the “Innenbereich” (interior) and “Außenbereich” (exterior) areas of a jurisdiction reflect where there is, and is not, housing generally. The residential density, especially, drives infrastructure options and requirements. In other words, the spatial planning determines the density, which can in turn influence the infrastructure (Moss, 2008, p. 447). In reverse, the infrastructure available also can determine whether an area is suitable for increased density. Thus, water infrastructure and spatial planning necessarily co-evolve and transform cities and places (Neuman, 2009; Moss, 2010, p. 226; McFarlane & Rutherford, 2008, p. 364).

Recently, non-conforming septic tank owners in Germany were schooled in European water quality policy. As the first EU Water Framework Directive (WFD) management plan cycle commenced in 2010, panic ensued for German homeowners with septic systems that allowed untreated or minimally treated wastewater to release into the ground. This typically involved a variety of septic tanks in which solids settled to the bottom of the tank while liquids passed either through permeable membranes or chambers into the soil for further filtration. According to German media reports, every second such system would need to be modernized or replaced, affecting approximately 500,000 residents nationwide (Haimann, 2009). Moreover, local newspapers highlighted cases, such as in the Trier-Saarburg region, where some 500 rural households reportedly could no longer use nonconforming septic tanks (Follmann, 2011).

As local wastewater managers in the German state of Rhineland-Palatinate went about working with residents to comply with the requirements stemming from the WFD implementation, infrastructures were modified that contribute to the centralized (e.g. sewers) or decentralized physical structure (e.g. small treatment plants) of their municipal wastewater systems. This matters because the nature of local wastewater infrastructure contributes to a city’s flexibility to adapt to demographic change (Moss, 2008) as well as to the potential use of urban and rural spaces. (For example, an area newly serviced by a central sewer becomes more attractive for development.)

Thus, these wastewater compliance changes present an opportunity to examine how wastewater infrastructure, water policy, and spatial planning interconnect in ultimately sustainable or unsustainable ways for the long-term. Here in this study, we consider WFD implementation at the local level through the use of a socio-technical perspective in the case of non-conforming septic tanks in Rhineland-Palatinate, Germany.

1.1. Wastewater infrastructure from a socio-technical perspective

Originally, basic onsite wastewater systems were the most immediate and obvious choice for dispersed societies, and such systems were by nature highly physically decentralized. Through the era of western industrialization and the growth of dense urban areas, large municipal central sewer systems became more common. These were not only essential in thwarting diseases such as cholera, but also points of pride and engineering prowess (e.g. the London sewer system in Johnson, 2006). Generally in public ownership, sewers offer completely centralized political control. Sewers are also a highly centralized technical solution that requires the ongoing flow of water, and they are designed and engineered for a certain usage/flow. Therefore, they represent the least flexible solution in terms of possible future demographic change (e.g. shrinkage), as demonstrated in parts of former East Germany (see Moss, 2008, p. 447).

The poor performance and accountability of many centralized systems have led to an increased interest in the advantages of decentralized systems, especially in low-income, peri-urban environments (Parkinson and Taylor, 2003). Because investments in sewers are sunk costs and cannot be recovered if the system is abandoned, the lack of flexibility suggests it would be important to develop transition scenarios for breaking out of this situation (Maurer, Rothenberger, & Larsen, 2005, p. 153). From an environmental perspective as well, Monstadt (2009) has noted that networked infrastructures are “inherently ambivalent: they can be seen both as a vital root cause of many environmental problems and resource shortages and as an important key to solving them” (1926). Moreover, technical innovation, environmental regulation, and concerns for sustainability, adaptability, and affordability are gradually shifting many regions globally back towards decentralized and on-site water systems (Bradley, Daigger, Rubin, & Tchobanoglous, 2002). On-site systems, such as septic tanks or small waste treatment units, present a variety of possible arrangements in terms of the roles for government, neighborhood groups, and individual households. The ownership and management of such systems can be a political and/or cultural issue, however. Nations with high usage of on-site systems, mainly conventional septic tanks, include the United States, Canada, Australia, Greece, and Turkey (Massoud, Tarhini, & Nasr, 2009, p. 654), and their regulatory oversight varies widely. In particular, the role of individual households as participants- and not just customers- in waste management, and the real or perceived risks involved, has been fodder for debate. For example, individual responsibility in wastewater (e.g. the maintenance of a septic tank) may be culturally more accepted in some countries than in others. Indeed, social acceptance is a major challenge to water managers when undertaking transformations to perhaps new and more sustainable water systems (Arora, Malano, Davidson, Nelson, & George, 2015).

Thus, a socio-technical perspective on wastewater infrastructure provides a lens for considering the implementation of the WFD at the local level that spans society, nature and technological infrastructures.

2. Methods

Because the WFD has led to new, additional, or modified wastewater infrastructures, there is a need to examine implementation at the local level. An English-language meta-analysis specifically on WFD studies concluded that the preparation phase of WFD implementation has been well-researched, especially on the process of drafting the first set of river basin management plans, but studies that cover the first management plan cycle are just emerging (Boeuf & Fritsch, 2016; Voulvoulis et al., 2017)). Moreover, only a minority of studies refer to theory when explaining WFD compliance and embed observations in their social, economic, or political contexts (Boeuf & Fritsch, 2016, p. 14). Implementation studies tend to use aspects of the WFD as a framework for analysis. A recent study

focused on ecological flows, economic analysis, incorporation of climate change, exemptions, public participation, and transboundary issues (Maia, 2017, p. 3044). Participation is also emerging as a strong thematic focus (Kochskämper, Challies, Newig, & Jager, 2016). Yet, research on the wastewater systems of ordinary, medium-sized cities and towns is largely missing. Thus, this study addresses an identified research gap by examining the WFD implementation from a socio-technical perspective at the scale of small and medium-sized municipalities.

A mixed-methods approach, including a questionnaire for local wastewater managers, semi-structured interviews with Rhineland-Palatinate state officials and other experts, and a review of policy documentation and data, was used to inform the case study (Baxter & Jack, 2008, p. 554). Building on the socio-technical infrastructures literature, the focus of the questioning here explored the moment of choosing between centralized, decentralized, or hybrid solutions as a result of new regulation. The German state of Rhineland-Palatinate is home to over 2300 municipalities, with the smallest number of residents per municipality in Germany (Junkernheinrich & Ziegler, 2013, p. 221). While the small towns generally possess the German decentralized concentration of population, there is a rural nature to much of Rhineland-Palatinate. For this study, wastewater managers from one municipal public works department per each of the 24 “Landkreise” (administrative districts) were contacted via e-mail and follow-up phone calls between November, 2016 and March, 2017 with questions regarding their implementation of the WFD regarding non-conforming septic tanks. The wastewater managers contacted were from primarily from medium-sized centers, according to the German central places categorization (Rheinland-Pfalz Landesentwicklungsprogramm or State Development Program).

In this study, wastewater managers were asked, how did their town comply with the WFD and what happened to the non-conforming septic tanks (mainly with outflows or permeable walls, “Sickergruben”)? According to one state official involved in the WFD implementation, such septic tanks already stood under regulatory scrutiny for many years due to the potential for biologically untreated wastewater to reach the groundwater (personal communication, 9 March 2017). The WFD management plan presented an opportunity to prioritize such retrofits as well as funding incentives. Alterations mainly included the following options: 1) to connect to a public sewer pipeline and treatment plant, 2) to install an individual or small group wastewater treatment plant, or 3) to install a closed septic tank (needing frequent emptying). Based on responses from wastewater managers, the study goal was to make a characterization as to the centralizing or decentralizing nature of the infrastructure solution. Of primary interest was the centralized or decentralized aspect of the material infrastructure. (While centralized or decentralized ownership and maintenance aspects are also critical, they can change more easily.)

3. Results and discussion

3.1. The case of Rhineland-Palatinate

Modern wastewater treatment in Rhineland-Palatinate developed mainly in the first several decades following World War II. As the state of Rhineland-Palatinate was founded in 1947, just 15% of the population was connected to a sewer and wastewater treatment (Rheinland Pfalz, 2014, p. 14). But by 1967 sewers reached 40% of the state’s population, and as of the end of 2014, 99.4 % of residents were connected to central public sewers (Rheinland Pfalz, 2014, p. 11). The small percent of remaining non-conforming septic tanks have been mainly, though not entirely, situated in exterior (“Außenbereich”) settings, either in rural natural or agricultural environments or the open space areas of urban ones, often the sites for small vacation cabins, garden huts, or farm homes. In German spatial planning, these exterior areas typically begin at the edge of the last concentrated settlement within a municipality and are generally to be kept clear of development, with a limited number of exceptions (see §35 German Building Code). While such areas do not represent a large percent of residents, these non-conforming

individual homes proved to be tricky, resource-intensive cases for wastewater managers implementing the WFD.

In order to help implement the WFD in the area of wastewater, in 2009 the state of Rhineland-Palatinate offered funding support to municipalities and individual households as part of the programs available under a 2010–2015 cycle. As such, 373.6 Million Euros in wastewater funding expenditures were part of the WFD program measures statewide between 2010 and 2015 (Hergenröther, 2016). Between 2013 and 2015, for example, a subsidy amount of 3,250 Euro was available from the state for a small on-site treatment system that serves four persons, and the total cost for such a unit may be 10,000 Euro (Rheinland-Pfalz, 2013).

When asked about solving the problem of non-conforming on-site wastewater systems, individual municipal wastewater managers shared a wide variety of experiences and challenges. Most respondents provided specific quantitative answers (e.g. the number of specific conversion from septic tanks to sewer connections), while others were only able to provide descriptive statements. Most of the projects mentioned by wastewater managers involved conversion projects in the exterior (Außenbereich) areas of their jurisdiction. Specifically, the following findings were drawn from the responses of wastewater managers based on their implementation projects during the management plan cycle.

3.1.1. Sewer connections

The main goal in all of the municipalities contacted remains to connect as many households to the networked central sewer system as possible. All other options were mentioned only if a sewer connection was not possible. Many municipalities had extended their sewer lines and added pump stations, sometimes for a small number of households. One municipality reported spending 736,000 EUR in order to make 21 sewer connections. Another spent 650,000 EUR for 2-3km of new sewer line, even though parts of their system were already in need of major repair.

3.1.2. Small wastewater treatment plants

There were a number of conversions to small treatment plants, which made use of a state subsidy. Here, experience with such systems varied greatly and were still seen as somewhat experimental. Several respondents indicated that they had no such systems at all, while others proudly reported a relatively large number (48 in one city, 30 in another). Surprisingly, operations and ownership of these units were mixed, private household and public.

3.1.3. Septic tanks

As most non-conforming septic tanks were removed from the municipalities contacted for this study, a surprising number of completely closed septic tanks persisted- and many are new.

Figure 2. A wastewater pump truck services a septic tank (Photo City of Pirmasens).



Table 1. Summary of wastewater manager response results

Tendency	Sample categorization	#
Centralizing	“In the city of X there are no conventional septic tanks with outflows. There are some permitted, closed septic tanks that we regularly empty through our mobile wastewater trucks. In consultation with the regional state permitting authority, we will not be pursuing any further decentralized wastewater systems.”	11
Hybrid	“The owners of previous three-chamber septic tanks have in consultation with the public works department decided on their future wastewater treatment as follows: - 18 biological small treatment plants - 9 retrofits to closed septic tanks - 18 central sewer connections, including about 2 km of new sewer line construction“	7
Decentralized (ing)	“no small treatment plants, in the center area all sewer connections, and in the exterior area about 350 closed septic tanks“	2
Not applicable (N.a.)	“In our municipality there were no conversions necessary.”	4
Total		24

*Responses from one municipality per each of the 24 state administrative districts
 Source: E-Mail and telephone responses to author, 2016–2017 (translated from German)

Servicing closed septic tanks requires a high level of communication between the residents and the wastewater managers around use, since the tanks collect all liquid and solid waste. Trucks (see Figure 2) then take the waste to the central wastewater treatment plant. In this study, the general range of closed septic tanks being serviced was between 20 and 100, though one municipality estimated that they regularly service 350 septic tanks. The wastewater fees collected typically must be set to be affordable enough so that residents aren’t tempted to take matters into their own hands. Thus, the closed septic tanks present an ongoing financial and environmental sustainability challenge.

3.1.4. Overall findings—centralizing tendencies

Responses from wastewater managers were categorized according to the nature of the system change (centralizing or decentralizing) due to compliance updates (changes from individual units to central sewers, etc). Here, several factors were considered: 1) where quantitative information was provided, the share of the changed wastewater systems were considered (e.g. mainly central sewers or mainly decentralized on-site units); 2) narrative statements specifically about the system tending to centralize or decentralize were noted; 3) extraordinary details in one direction or another were also included in the analysis. Altogether in Table 1, sample responses are quoted, and their corresponding categorization is shown. It is striking that only two responses showed a decentralizing tendency.

3.2. Discussion

Based on the response analysis and additional expert interviews, two main outcomes of the WFD implementation in Rhineland-Palatinate can be seen. First, the WFD mainly added concrete enforcement dates as well as funding from the state government to help enforce wastewater policies that were more or less already in place. Dr. Thomas Rätz of the Gemeinde- und Städtebund Rhineland-Palatinate noted, the WFD “generated pressure” to solve known problems (personal communication, 14 November 2016). According to a state official interviewed, the WFD primarily served as measure for enforcing wastewater policies (personal communication, 8 March 2017).

Individual wastewater providers implemented centralizing solutions where possible (see Table 1), due to a variety of technical, political and perhaps cultural reasons. Dr. Rätz at the Gemeinde- und Städtebund Rhineland-Palatinate (The Town and Cities Association) noted that “while there are some decentralized (wastewater) solutions, it cannot be said that there is a decentralizing trend,” (telephone communication 14 November 2016). Perhaps the

relatively late introduction of the small wastewater treatment plants grant subsidy, which began in 2013, could have played a role. In a statement made by the Rhineland-Palatinate Minister for the Environment, Ulrike Höfken praised the subsidy for the small treatment plants and stated that the state saved 20 million Euros through decentralized solutions (Rhineland-Pfalz, 2015). While this may nonetheless count as a success, its impact on local infrastructure planning as a share of the conversions completed towards WFD compliance was modest.

Given the strong showing of centralizing or hybrid tendencies in wastewater infrastructure projects for this study, each categorization was also compared to general development of the municipality (shrinking or growing). For this comparison, data from a federal institute (Bundesinstitut für Bau-, Stadt- und Raumforschung, 2014) study was utilized. Shrinking municipalities showed centralizing (5) or hybrid (5) tendencies. Interestingly, the only two decentralizing tendencies were actually found in growing municipalities. Together, this outcome was the opposite of what one might expect or even recommend. Normally, one might expect negatively developing municipalities to be attuned to the benefits, such as flexibility and cost, of decentralized wastewater solutions. The federal German water report also urges rural areas, in particular to consider the aging and declining rural population, and thus a diminishing flow of wastewater, as a factor in wastewater planning (Umweltbundesamt, 2016, p. 138–139). Here, the experience gained through the small wastewater treatment plant subsidy could perhaps be a starting point for more targeted outreach around wastewater infrastructure planning in order to help shrinking towns consider decentralized infrastructure options where possible.

Still, in the big picture, one must wonder how significantly the less than one percent of households in Rhineland-Palatinate unconnected to sewers actually contributed to water pollution. Or in other words, could the money spent on this aspect of compliance have been more effective in other water protection projects? After all, much of the new infrastructure developed turned out to be in rural areas where there is space and soil, generally speaking, for natural infiltration processes.

Moreover, in Rhineland-Palatinate, current sewer repair needs total approximately 1 Billion Euros (Theis, 2016). In a sense, the WFD implementation and the mobilization of resources around it ultimately contributed to the further build-out, perhaps even an over build-out, of a networked, centralized infrastructure that will be less flexible and more costly to maintain in the future—and one that already awaits repair in many areas. Municipal wastewater managers seized the chance to reign in and network the outlying areas, effectively spatially reformatting, as per Monstadt (2009, p. 1934), the formerly disconnected areas and eroding distinctions between the outlying and interior populations. The build out of such infrastructure in the exterior could tempt, for example, local planners to permit more privileged uses in the exterior natural and agricultural spaces.

4. Conclusion

Naturally, the WFD implementation did further limit untreated wastewater's reach to the surface and groundwater, but there may be a lack of balance with respect to environmental and fiscal sustainability factors. In Rhineland-Palatinate today, trucks drive around collecting waste from closed septic tanks at outlying homes in perpetuity. Many new kilometers of central sewer lines and pump stations today connect previously unconnected dwellings. Will they be needed in the future?

While EU, federal and state regulations apply, the individual towns and cities still hold a great deal of autonomy with respect to wastewater infrastructure decisions. This makes their choices collectively interesting to consider in terms of a variety of societal, economic, and sustainability factors, perhaps even revealing of a local wastewater culture.

Future research to support European, federal, and local wastewater policy is needed. Such research should, ideally, be culturally-sensitive and comparative in nature, as recommended by (Spiller, McIntosh, and Seaton, 2012). Interdisciplinary research, such as studies spanning hydrology and geography or spatial planning, could critically explore and quantify the merits or drawbacks of specific water protection projects. Especially in light of demographic change occurring in

many rural areas, a nuanced analysis should weigh the cost of infrastructure investments with other options for water protection (or the need for exemptions).

As Reimer and Blotevogel have noted in the spatial planning literature, “certain tendencies towards harmonization at the European level may run parallel to processes resulting in the heterogenization of planning practice at the micro level” (2012, p. 8). If we are to support effective, sustainable water quality goals in Europe and beyond, researchers and policymakers should keep close to local planning and management realities.

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