Steps towards implementing decentralized rural sanitation solutions: An institutional assessment of the Brazilian sanitation sector

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Abstract
In spite of a great number of environmental laws and a sound legal framework for the water and sanitation sector, there are numerous obstacles, which impede the successful implementation of Brazilian sanitation policies. This study undertakes an institutional assessment of decentralized wastewater treatment solutions, applicable in rural areas in the state of Rio de Janeiro in order to identify governance potentials and constraints of the Brazilian rural sanitation sector. The results of a legal and institutional analysis on federal, state, river-basin (Paraíba do Sul) and municipal levels apply on a case study, conducted within the INTECRAL project in a rural settlement in the municipality of Nova Friburgo, with the purpose to identify necessary procedures for the implementation of a pilot wastewater treatment solution. This article defines the major challenges of the Brazilian rural sanitation sector and reflects the applicability of the proposed decentralized collective wastewater treatment and reuse solutions on the regional case study level from the institutional and legal as well as from the operation and maintenance model perspectives.

Keywords
Rural sanitation in Brazil, institutional assessment, decentralized rural sanitation solutions, wastewater treatment

INTRODUCTION

Brazil holds over 12% of the planet's water supply. Nonetheless, it experiences strong water pollution along the high populated coastal areas and water deficit in the industrialized south-east and north-east regions (Formiga Johnsson 2014). Furthermore, agricultural areas are affected by pesticide load and the absence of sanitation facilities. Rural areas, being important water and food suppliers, require not only technological but also institutional solutions to prevent environmental and health hazards. The Brazilian sanitation sector experiences multiple structural deficits and challenges to be approached. Despite a firm nationwide institutional and legal sanitation framework, it still lacks clear responsibilities for water supply and wastewater treatment in rural areas, which present poor sanitation and public health conditions as well as diverse environmental problems. Since water supply in rural and remote areas is mostly provided by wells and is free of charge, the allocation of responsibilities and costs for initial investment and maintenance of water and wastewater treatment solutions becomes challenging (Kreter 2015).

This study undertakes an institutional assessment of decentralized wastewater treatment solutions suitable for small low-income communities with population from 500 to 1500 inhabitants in the state of Rio de Janeiro (RJ). The local case study, conducted within the German-Brazilian academic research project INTECRAL in a rural settlement in the municipality of Nova Friburgo, points out the institutional and legal potentials and obstacles for the implementation, operation and

maintenance of the proposed decentralized collective wastewater treatment and reuse solutions with the objective to improve the sustainable management of water resources.

INTECRAL (Integrated Eco Technologies and Services for a Sustainable Rural Rio de Janeiro) is a German-Brazilian scientific cooperation project supported by the German Federal Ministry of Education and Research (BMBF) and the State Secretariat of Agriculture and Livestock Project RIO RURAL (SEAPEC-PRR), aiming to improve the competitiveness of the Brazilian rural economic sector considering sustainable watershed management, environmental risk mitigation and protection of natural resources (INTECRAL).

MATERIALS AND METHODS

The purpose of this article is to analyse the existing institutions within the Brazilian sanitation sector by the rules, provided by the legal framework; and processes, emerging from the interaction between the existing stakeholders under the given legal framework. The analysis follows an applied and pragmatic approach devoid of theoretical background in order to identify the existing deficits and potentials of the Brazilian sanitation sector and consequently, define steps towards implementing decentralized rural sanitation solutions. This work mainly focuses on wastewater treatment in rural areas in the state of Rio de Janeiro taking into account the peculiarity of rural housing conglomerates. As the Brazilian sanitation legislation defines “basic sanitation” as a set of services including fresh water supply and solid waste management, and there is a lack of an explicit national rural sanitation policy, the entire concept of Brazilian “saneamento” will be discussed for the legal and institutional assessment on macro and meso levels, covering the national, state, river basin and municipal policy and institutional levels, in order to apply the results on a case study for decentralized rural sanitation solution on a micro level.

Additionally to an extensive legal framework analysis, including policy documents and acts, a total of 24 semi-structured interviews were conducted on federal, state, river basin (Paraíba do Sul River Basin and its integrated river basin, Rio Dois Rios) and on municipal levels to provide a holistic overview over the sanitation sector, with a focus on rural sanitation in Brazil and RJ.

RESULTS

Legal Assessment

Historically, water resources management in Brazil has been centralized and focused on the hydro-electrical sector. In 1997, Brazil launched a national water resource management reform, which introduced integration of sectoral policies, decentralization of water resources management, allocation of decision making competence on river basin level and increased stakeholder participation (Engle et al. 2011). Although these laws establish requirements to ensure the sustainability of sanitation investments, there is a predominance of discursive omissions and ambiguous visions within the same legislation (Souza et al., 2007). The unclearly defined duties and the coherent uncertainty (e.g. responsibility for water losses or regulation of rural sanitation) tend to create uncovered sectors and/ or overlapping of actions on federal, state, and municipal levels (Bevilacqua Leonetti et al., 2011). Under the current Brazilian legislation, there is no particular national policy for rural sanitation.

Thus sanitation of rural areas is supposed to form a part of municipal basic sanitation plans. According to the Sanitation Law (Law 11.445/2007), each of the 5,565 Brazilian municipalities is responsible for the elaboration and implementation of its basic sanitation plan, covering both, urban

and rural areas. It is also within the responsibility of the municipalities to find resources for elaboration and implementation of a municipal basic sanitation plan, decide about the provision of sanitation services (directly or delegated), adopt parameters for drinking water quantity, regularity and quality in order to guarantee public health; to define entities responsible for the regulation and supervision of sanitation services; the rights and duties of service users; to establish mechanisms for social participation and control among others (Federal Law 11.445/2007). However, most Brazilian municipalities experience serious challenges with the elaboration of their basic sanitation plans due to low technical and financial capacity and have difficulties to contract well skilled technicians, capture federal and state resources designated for sanitation actions and elaborate sound sanitation projects. The Brazilian government extended the term for the nationwide completion of municipal basic sanitation plans already for the third time until 2015. The first term for accomplishment was set for 2010 and postponed for 2013 in the second phase. However, only 12% of the Brazilian municipalities delivered well designed municipal basic sanitation plans according to the law requirements by 2014, seven years after passing the bill (Instituto Trata Brasil 2014).

Institutional Assessment

Under the Brazilian decentralization concept, the state delegated management and decision making power over defined policy areas to lower governmental levels, such as municipal councils or stakeholder committees (Brannstrom 2004). Depending on the policy area, decentralization may underlie different division concepts such as administrative/ or political (e.g. cultural, education, finance, environmental sectors) and hydrographic division (water sector). Under the approach of Integrated Water Resources Management (IWRM), the Brazilian water and environmental sectors are strongly interconnected, which allows environmental institutions, such as executive state agencies under administrative division also work under the hydrographic division (e.g. Rio de Janeiro State Environmental Institute (INEA)). Hence, Brazilian executive and legislative environmental and water institutions on federal, state and river basin levels are interrelated and assume cross-sectoral duties, looking back to a long standing cooperation. In contrast, the recently emerged Brazilian sanitation sector does not show strong institutional interrelations with other sectors and delegates management and decision making power related to sanitation actions directly from the federal to the municipal level. However, despite the decentralization, a significant amount of power in policy design and implementation as well as in distribution of financial resources remained on the federal level (Engle et al. 2011), which makes it challenging for the municipalities to keep their autonomy and comply with the federal requirements.

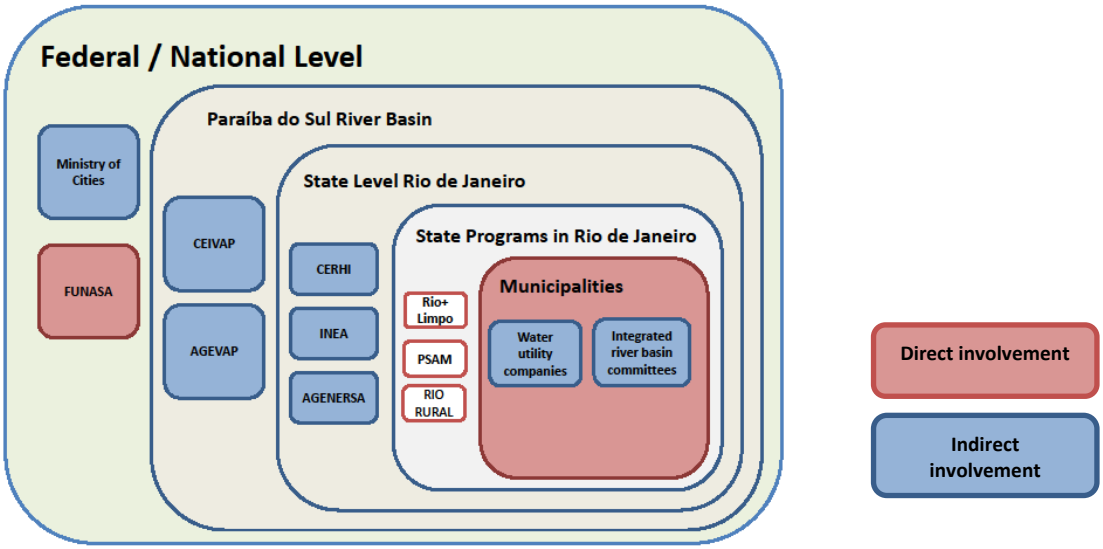
The Brazilian sanitation programs and institutions on the national level have a strong focus on urban sanitation. Nonetheless, various federal and national ministries implement sanitation programs, including rural sanitation actions, which are rather scattered and selective.

The Ministry of Cities and the National Health Foundation (FUNASA) coordinate and provide financing for basic sanitation plans for municipalities on the federal level. The Ministry of Cities is responsible for municipalities with more than 50.000 inhabitants while FUNASA attends municipalities with less than 50.000 inhabitants within the entire municipal territory. Furthermore, FUNASA is currently developing a National Rural Sanitation Plan (expected by the end of 2016/ beginning of 2017) as was delegated the responsibility for rural sanitation nationwide by the Sanitation Law No. 11.445/2007.

Although not being responsible for sanitation actions by law, water resources management stakeholders began recently engaging in rural sanitation: The Integration Committee of the Hydrographical Basin of the Paraíba do Sul River (CEIVAP), a committee of a physically highly complex river basin, covering three Brazilian states: São Paulo, Minas Gerais and RJ, started

financing the elaboration of the basic sanitation plans from water use charges from the Paraiba do Sul River for all river basin affiliated municipalities, which were not able to obtain any federal, state or private funding in order to advance the progress in sanitation. The executive agency of CEIVAP**,** the Paraíba Valley Agency (AGEVAP), also turned into an important sanitation stakeholder by moving forward the sector development and finding solutions for challenges, which could not be approached within the existing governmental institutional setting (e.g. the agency elaborated rural sanitation diagnostics for seven municipalities in the state of RJ in 2015).

Figure 1. Stakeholders directly and indirectly involved in rural sanitation actions allocated on the respective governance levels: federal/ national, Paraíba do Sul River Basin, State of Rio de Janeiro and municipal levels.



On the state level, the Brazilian states compromised under the Pact for Basic Sanitation (Pacto Pelo Saneamento Basico) with the National Basic Sanitation Plan – PLANSAB, and have acted predominantly in the development and coordination of state sanitation programs, service provision for drinking water supply, wastewater collection and treatment through state owned companies and recently, in the regulation of services through regulatory agencies. The urgency for sanitation actions on the state level was also recognized by water management organizations on the state level such as the Council for Water Resources of the State of RJ (CERHI)**.** CERHI is a state collegiate body with regulatory, consultative and deliberative powers, responsible for the implementation of the State Water Resources Policy, which declared sanitation as priority for investments within its guidelines. Accordingly, 70% of the resources of river basin committees generated by charges for water use in RJ need to be invested in sanitation actions by CERHI Resolution No. 86/2012 and State Law No. 5.243/2008. However, CERHI doesn't liberate financial resources for sanitation programs and actions and only designs water resources management policies in the state of Rio de Janeiro. The State Environmental Institute (INEA), an environmental management agency of the state government of RJ, linked to the State Secretary of the Environment (SEA), manages those funds for each hydrographic region of the state and also operates as executing secretary of CERHI.

The newly established regulating agencies (RAs) might start playing a significant role for rural sanitation in the near future. Regulating agencies are autonomous, economically independent entities, which can be formed on state or municipal level and represent an equilibrating mechanism

between municipalities, service providers and society to regulate interests, costs and demands for water supply and sanitation. RAs are also supposed to control and overview the sanitation service provision contracts associated within the municipal basic sanitation plans in the future; consequently, rural sanitation needs to become part of regulated municipal service provision. However, the regulating agency for energy and sanitation of the State of Rio de Janeiro, AGENERSA (Agencia Reguladora de Energia e Saneamento Basico do Estado do Rio de Janeiro)), founded in 2005, regulated eight of the 92 municipalities in RJ in 2015, while none of the regulated water supply and sanitation service contracts covered rural areas.

On the Rio de Janeiro state level various programs to face rural sanitation as a subdivision of the state sanitation actions have been launched. The mayor state sanitation program is “RIO + LIMPO” (River+Clean), a program in partnership with the state company for water and sewage treatment (CEDAE), the State Secretary for Agriculture and Livestock and municipalities, aiming to collect and treat 80% of the sewage in RJ until 2018, including sanitation solutions in 45 rural locations. However, the efficiency of the program is very low due to the weakness of the management system for sanitation services on the state level. The responsibilities for various actors involved in planning, managing, monitoring and regulation of sanitation projects remain unclear and uncoordinated. Another program, the Environmental Sanitation Program for Municipalities of Guanabara Bay (PSAM), a sub-program of “Rio+Limpo”, aims to strengthen state institutions like AGENERSA, INEA, CEDAE, SEA and to develop sustainable municipal sanitation politics. PSAM supports the development of municipal basic sanitation plans around the Olympic area, Guanabara Bay and plans the implementation of sanitation solutions in smaller communities. Another sub-program of “Rio+Limpo”, RIO RURAL, coordinates rural sanitation actions in projects for individual and collective rural sanitation solutions in three selected priority regions within the most vulnerable priority watersheds under the State Secretariat of Agriculture and Livestock.

Identified institutional and legal obstacles

The Brazilian rural sanitation experiences a strong legal and institutional vacuum, accompanied by poor fulfillment of the existing laws and low communication between the accountable institutions. The priority of federal politics is given to urban development while rural development drags behind, lacking a nationwide rural sanitation program. On the RJ state level there is also a great need for well-designed and integrative rural sanitation projects and programs within the state water resources management system. One of the major challenges is the absence of control mechanisms on higher governmental levels to assure the longevity of sanitation programs, projects and implemented solutions, given that the transfer of funds for sanitation plans, programs and actions is not conditioned to delivery of final targets. The social control mechanism through civil society, embodied in the Sanitation Law and PLANSAB, is weakly rooted in Brazil. The municipalities are often simply overstrained with the responsibility to plan, design and implement sanitation concepts for urban and rural areas, devoid of technical and institutional assistance. However, the urgency for sanitation action combined with the lack of strategic planning lead to appearance of spontaneous initiatives to overcome the existing institutional gap in the Brazilian sanitation sector, such as in case of the Paraíba do Sul River Basin water management agency AGEVAP, facilitating basic sanitation plans, solid waste management and rural sanitation actions in the integrated river basin municipalities.

Identified institutional and legal potentials

The Brazilian rural sanitation challenge can be only approached by closing the institutional loophole around executive duties for service provision, support and regulation of the sector. Moreover, the strengthening of monitoring and control over the adequate planning and implementation of sanitation projects, plans, programs and actions is necessary to assure long term

operation and sustainability of sanitation actions.

An essential requirement to overcome the difficulty of municipalities to elaborate and implement basic sanitation plans is the formation of inter-municipal consortia and integration of multiple stakeholders into the design and implementation process. Brazilian municipalities already have a longstanding expertise in formation of inter-municipal consortia, considered to be the strongest in Latin America (Brannstrom 2004, Nickson 1995). The RJ states program “LIXÃO ZERO” (zero open dump program for solid waste management) showed a good example for a successful municipal joint “saneamento” action, which also could be replicated on rural sanitation. Moreover, the creation of further economic incentives, in addition to the existing spring preservation program “Produtor de Agua” (national payment for ecosystem services program introduced by National Water Agency (ANA)) and ICMS-Verde (RJ state tax on goods and services reimbursed as revenue to municipalities, which invest in environmental conservation, including sanitation) would push the progress in rural sanitation.

CASE STUDY: INSTITUTIONAL ASSESSMENT

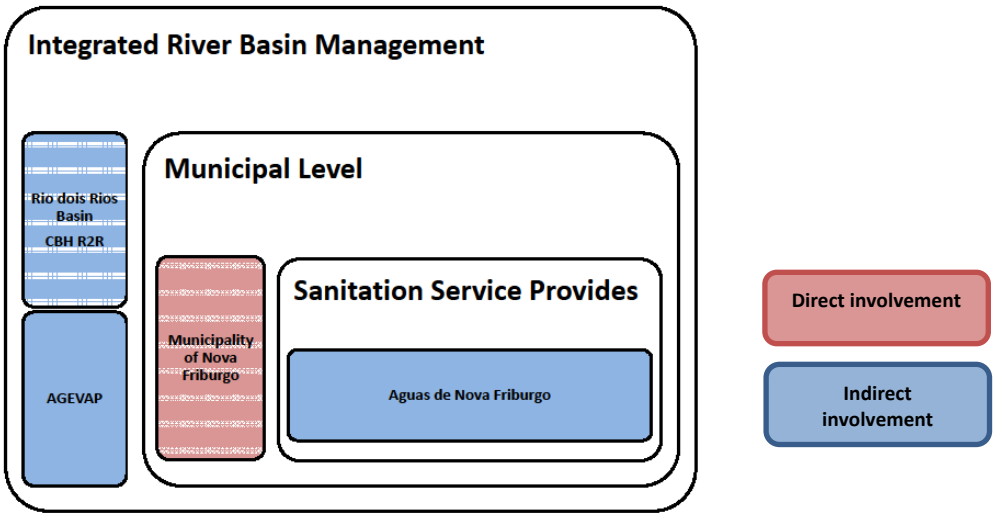
In order to represent the diverse interactions and interrelations between the actors related to decision making and executive processes as well as the existing institutional gap around rural sanitation in Brazil, we conducted a case study for a pilot decentralized collective sanitation solution in a rural community in the municipality of Nova Friburgo, RJ within the framework of the INTECRAL and the RIO RURAL projects.

The community of Barracão dos Mendes (BdM) reflects the currents constraints of the numerous small urbanized communities in rural areas with around 1000 inhabitants: Like in most Brazilian rural communities, the households of Barracão dos Mendes have simple on-site solutions called “Fossa Negra” (septic tanks without a sealed bottom, where discharged wastewater leaches underground) or no domestic wastewater treatment systems at all. Assuming that Fossas Negras are allocated nearby water catchment areas, where the local population extracts drinking water from wells without any further treatment, contaminated ground water may create risk for diseases, especially for diarrhea. Due to the absence of a sewer network, untreated wastewater flows into a river and create risk of pathogens entering the food cycle through irrigation with water from the river (Böttger et al., 2014).

In the following, the governance structure, associated with decision making and executive processes around decentralized sanitation solutions on the municipal and integrated river basin levels is summarized, followed by the description of project development, institutional setting and peculiarities of the project related stakeholder constellation.

Rural communities belong to their administrative municipal territories and need to demand sanitation services at their municipal administrative centers. The municipality of Nova Friburgo has a comparatively well-organized political and administrative structure and was accomplishing the municipal basic sanitation plan by the time period of the realization of the case study. The water supply and sanitation service provision was delegated to a private concessionaire, which operated three centralized wastewater treatment plants in the municipal area. The concession between the service provider and the municipality of NF only covered urban areas and was not regulated.

Figure 2. Stakeholders directly and indirectly involved in rural sanitation actions on the integrated river basin (Rio dois Rios) and municipal (Nova Friburgo) levels.



The municipality of Nova Friburgo comprises two hydrographic regions (Rio dois Rios and Rio Macaé) belonging to the Paraíba do Sul river basin. The integrated river basin is administrated by the river basin committee Rio Dois Rios (CBH R2R) and managed by AGEVAP as its executive agency. The committee does not have sufficient financial power to implement river basin wide sanitation programs and actions and focuses rather on financing of project planning for scattered sanitation actions within the river basin area. AGEVAP operates as an administrative and executive organ via its R2R nucleus, e.g. arranging contracts and terms references with municipalities and other stakeholders, announces public tenders for projects, etc. on behalf of AGEVAP and CBH R2R.

Technology choice

From the perspective of municipal authorities, identified as major decision takers, a careful selection of wastewater treatment technologies needs to be undertaken. In this context, the choice of decentralized wastewater treatment technologies for rural areas depends particularly on factors such as population density, climate, geography, hydrogeology and other environmental, technical, institutional and financial factors (van Afferden *et al.* 2015). To assure the longevity for functioning of rural wastewater treatment solution, simple decentralized technologies with low dependence on human intervention for maintenance (pumping system, electricity) and low complexity are most suitable (Massoud *et al.* 2009). In contrast, rural nuclei with high population density will require a more complex technological solution; while individual wastewater treatment solutions are generally more reasonable for rural areas with disperse housing. Overall, decentralized wastewater treatment solutions would be more suitable for remote, low populated and mountainous regions.

Challenges identified within the case study

The major challenge of the rural sanitation project in Barracão dos Mendes was to assign the responsibility for the operation and maintenance of the pilot wastewater treatment plant (WWTP). Although the municipality of NF is responsible to plan and implement proper sanitation solutions within its territory, it was not involved in the project development from the beginning. Instead, the action has been taken over by water and environmental sector stakeholders: the previous field research on the area was undertaken by RIO RURAL in cooperation with the Fluminense Federal

University. Subsequently, the river basin committee Rio Dois Rios (CBH R2R) financially contributed to the development of the executive technical project, while the technical project design was assumed by AGEVAP. Additionally, the agency offered trainings followed by two years of supervision for the operation and maintaining staff of the planned pilot WWTP in BdM.

Another challenge regarding the operation and maintenance of the WWTP in Barracão dos Mendes was sludge disposal. Sludge from the WWTP can be disposed in landfills using the existing infrastructure of the municipal water supply and wastewater treatment service provider. However, this solution might generate additional costs for the community, such as monthly payments for landfill disposal, tariff collection system etc. Though, treated sludge contains organic nutrients and could be used as a fertilizer in agriculture. The on-site sludge treatment would reduce transportation and landfill disposal costs, generate income for the community through organic fertilizer (humus) production and consequently lead to the reduction of agro-toxics (Kreter 2015). Nonetheless, the direct agricultural use of sludge from wastewater treatment is strongly restricted by the CONAMA (National Environmental Council) state resolution No. 375/06.257 (Art. 11), determining that sludge can be used in agriculture only meeting strict quality requirements, not fulfilled within the project selected technologies.

RESULTS AND DISCUSSIONS

The case study pointed out the necessity of appropriate wastewater treatment solutions in rural areas of RJ and introduced an example of economically feasible wastewater treatment technologies in accordance with technical and environmental standards as well as an alternative option for sludge reuse. It also underlined the importance of municipal involvement for a successful implementation of rural sanitation solutions in all project spheres: from the executive project development to land acquisition, to the operation and maintenance and development of financing mechanisms. The intervention of water agencies such as AGEVAP, operating as an enforcing and executing institution within the project, emphasized the need for the introduction of supporting organisms for the progress of rural sanitation. Also the communication and interrelation between the municipality and water resources management institutions (river basin committee CBH R2R and agency AGEVAP) resulted low. Regarding technology choice, due to the difficulties of the allocation of responsibilities for maintenance and operation of the decentralized wastewater treatment solution, it is worthy of consideration, if rather an alternative collective low cost and easily operable system with low energy and maintenance costs, which could be operated by community members without a special technical knowledge, such as constructed wetlands and collective bio-digesters, would be more suitable for BdM.

Also the allocation of responsibilities and costs for operation and maintenance of decentralized wastewater treatment solutions proved challenging. In small rural communities such as BdM, water provision is free of charge and might entail unwillingness to pay for sanitation services. Therefore, introduction of a tariff system to provide long term sustainability of the sanitation service provision in rural areas would be crucial. Moreover, low-income rural communities with low ability to pay for sanitation service provision, require particular sustainable financing mechanisms, such as subsidies and tailored tariffs. Additionally, the case study introduced the need for a particular wastewater treatment tariff, separated from the water supply tariff. Especially in rural communities, where wastewater treatment measures have priority to drinking water supply, the ligation of the water supply tariff to the wastewater tariff hinders the fair calculation for a separate wastewater treatment price in many rural communities in RJ. The creation of new incentives and the adoption of existing ones, such as tax revenues on municipal sanitation actions (e.g. ICMS-Verde), might subsidize rural sanitation actions on the municipal level and favour the implementation of collective rural

sanitation solutions without cutting municipal budgets.

Further, the case study opened a debate on the importance of sludge reuse in agriculture. For agricultural areas sludge reuse would be an economically feasible solution contributing to additional revenues through the sale of stabilized and treated sludge as fertilizer. Moreover, the reuse of stabilized sludge would reduce the use of agro-toxics.

CONCLUSIONS

Rural sanitation is at risk to remain an unattended subdivision of municipal basic sanitation and an unmet requirement of the Brazilian national sanitation concept until the existing policies experience a strategic enforcement at all levels of government, going along with continuous funding and joint action of the involved stakeholders. Today, the articulation of national policies diverges widely from their implementation due to the lack of technical know-how at the municipal level, while institutional discordance about the responsibility for the rather unprofitable sanitation service provision in rural areas drags the investments in water supply and wastewater treatment solutions in small rural communities.

The indistinctness regarding the responsibility for the rural sanitation at all governmental levels was evident on the case study level. Also the importance of political goodwill of the municipal authorities for the advance of rural sanitation was brought to attention within the case study. Therefore, introduction of supporting and enforcing institutions as well as creation of regulatory and control mechanisms is crucial to push the rural sanitation progress towards achievement.

In general, it can be said, that there is no overall and singular solution for Brazilian rural sanitation projects due to the differences and peculiarities of premises and factors of each region and stakeholders involved. However, the institutional and legal gaps around rural sanitation leave space for initiative action and introduce the need for interrelation with the existing institutions in the water and environmental sectors.

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