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Decentralized and onsite wastewater management issues of small communities in the Jourdan River Watershed, Mississippi

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Abstract: Wastewater treatment and nutrient removal alternatives for large size communities are very well-established and are feasible in many cases. When it comes to the small rural and especially for low-income disadvantaged communities, this is not the case, particularly with regard to nutrient removal. The alternatives for small communities are often viewed as cost-prohibitive and unreliable. While this is partly true, careful selection and implementation of appropriate technologies can result in high performance, energy and cost efficient and environmentally friendly solutions. Assessment of water and wastewater is very crucial to safeguard public health and the environment. However, water quality data on fresh and marine waters in the Mississippi coastal region, especially in Jourdan watershed are still sparse and uncoordinated. Therefore, monitoring these parameters is important for safety assessment of the environment and human public health and the water bodies. We have identified a few small and decentralized communities in the Jourdan River watershed area to assess the current wastewater treatment and management practices and their impacts on the receiving water bodies. This paper will discuss our preliminary evaluation and understanding on the local water quality issues of the watershed.

Keywords: nutrient removal; decentralized communities; onsite wastewater management, septic tank, Jourdan River watershed, Mississippi coastal waters

1. Introduction

Wastewater treatment and nutrient removal alternatives for large communities are generally well established. When it comes to small rural communities, however, this is not the case, particularly with regard to nutrient removal. The alternatives for small communities are often cost-prohibitive and require a higher level of maintenance. If these systems are not maintained correctly, they will not perform reliably and are likely to fail well before the end of their design life. Poorly maintained or failing onsite wastewater treatment systems contribute to surface water pollution. In the Jourdan River watershed, failing septic systems have led to its classification as a priority watershed for fecal contamination [1], [2]. Tributaries of the Jourdan River have also been identified as impaired waters with low dissolved oxygen and high levels of bacteria due to nutrient enrichment, which can also be attributed to failing septic systems [1]. The current wastewater treatment and nutrient removal practices in certain communities surrounding tributaries of the Jourdan River are being evaluated to determine their performance and reliability. The following sections provide an overview of the coastal communities of Mississippi which are in serious need for wastewater management to protect the receiving water bodies.

2. Background and current issues

This section will describe the current status of wastewater treatment and management systems in disadvantaged (underprivileged) communities of Jourdan River watershed. By word "disadvantaged", we mean the communities that are rated a low priority for advancement and low income communities. Figure 1 shows the coastal counties that are within 50 mile reach to the shoreline in Mississippi and their land uses [3]. These are George County, Stone County, Pearl River County, Jackson county, Harrison county and Hancock County. It can be noted that the coastal areas have medium to high intensity development while the other areas have a low intense development.

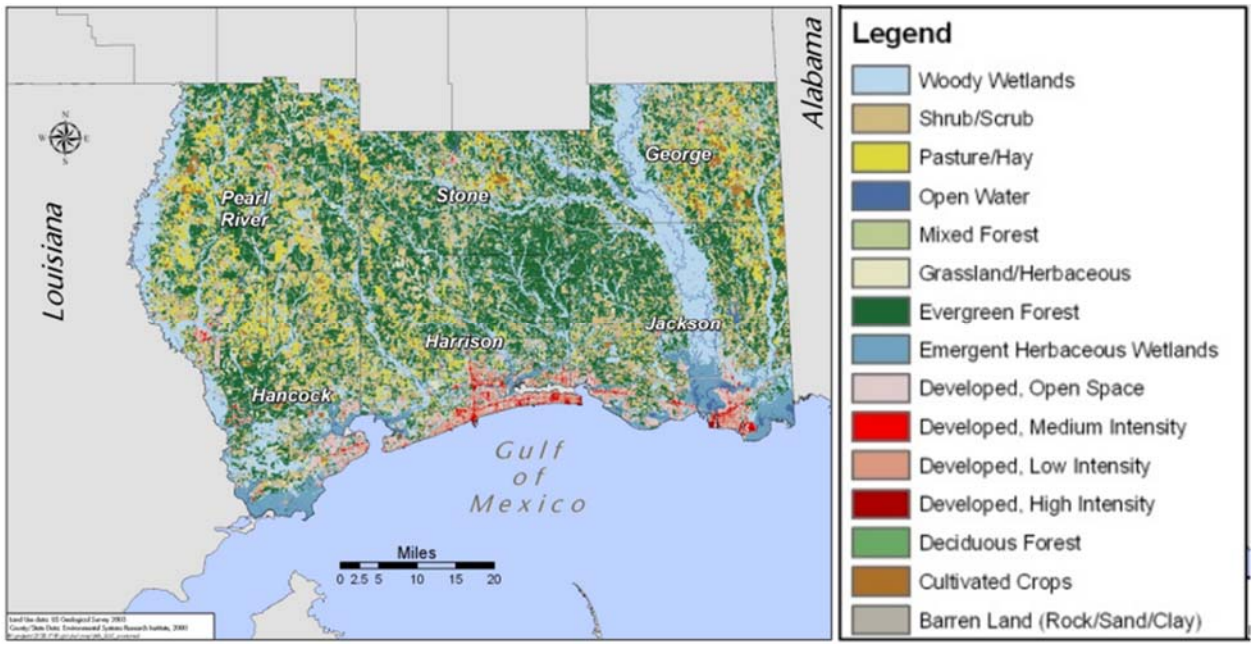

Figure 1. Mississippi coastal counties and land use in these counties.

2.1. Wastewater treatment and management in coastal counties

Sanitary sewer service is unavailable in large parts of the Gulf Region, particularly in unincorporated areas. The residents and businesses in these areas operate individual onsite wastewater treatment and disposal systems. These units typically consist of septic tanks and absorption fields located on the property where the wastewater is generated. These systems tend to fail with poor maintenance and inappropriate soil applications. An estimated total of 7.3 million gallons per day of improperly treated sewage is released into the environment from failing individual on-site systems in the Gulf Region. Soils in the Gulf Region generally are not conducive to installation of absorption fields for septic tanks. Relative suitability ranges from about 8 percent in Hancock County to about 75 percent in George County [4]. When soil conditions will not support effective operation of septic tanks and absorption fields, residents must use aerobic treatment systems. These mechanical systems are more complicated to operate than septic tanks and often fail due to lack of maintenance by homeowners. Figure 2 presents the statistical data of onsite treatment units in the six counties. It can be noted that Jackson County has a majority of failing units and an estimated total flow of 2.24 MGD followed by Harrison County with an estimated flow of 1.9 MGD. Table 1 shows a comparison of the wastewater treatment systems suitable for onsite wastewater management. Conventional (septic tanks with absorption field) are economical with lower capital and operation and

maintenance costs. Intermittent and recirculating sand filters perform better than the conventional system albeit at a higher capital and operation/maintenance costs.

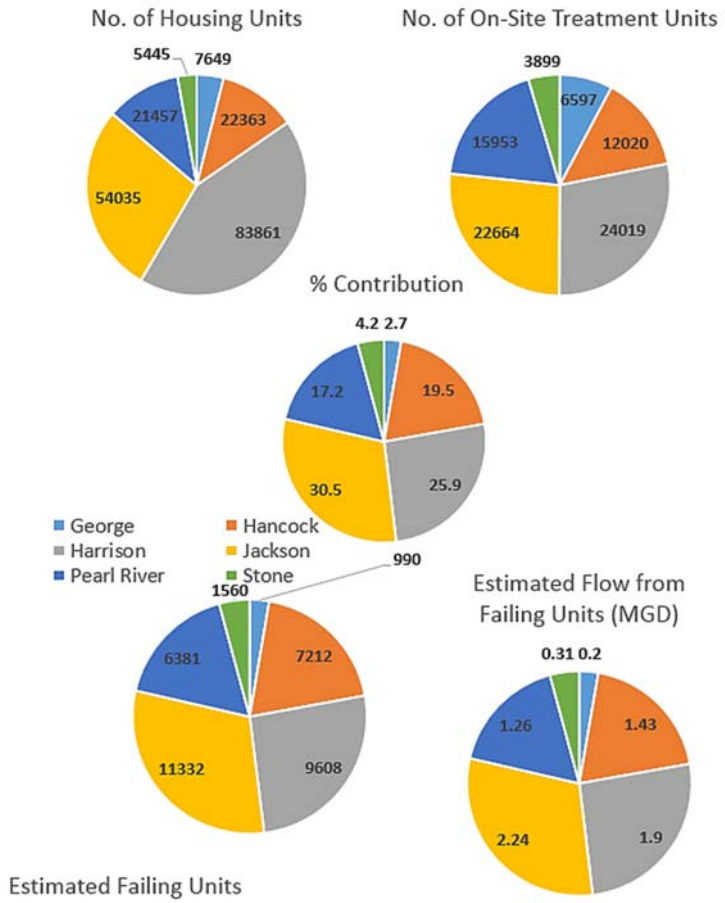

Figure 2. Number of housing units with onsite treatment units, failing units and the estimated flow in MGD from the six coastal counties of Mississippi

Table 1. Comparison of current on-site wastewater treatment systems

System	**Cost**		**Treatment Levels**			
	Installation	***Annual***	***BOD*$_5$**	***TSS***	***Nitrification***	***Denitrification***
Conventional	$1,500 - $4,000	$250 - $550	10 mg/L	10 mg/L	-	-
Intermittent Sand Filter	$10,000	$155 + Power	95% Removal	85% Removal	80% +	-
Recirculating Sand Filter	$25,000 +	$350 + Power	95% Removal	95% Removal	Near Complete	Up to 50%

2.2. Socioeconomic aspects

As shown in Figure 3, around 40-50% of the population in these counties can be classified as low to moderate income families [5]. It is important to provide cost-effective onsite treatment systems for these communities as the affordability for installation and operation/maintenance is not favorable.

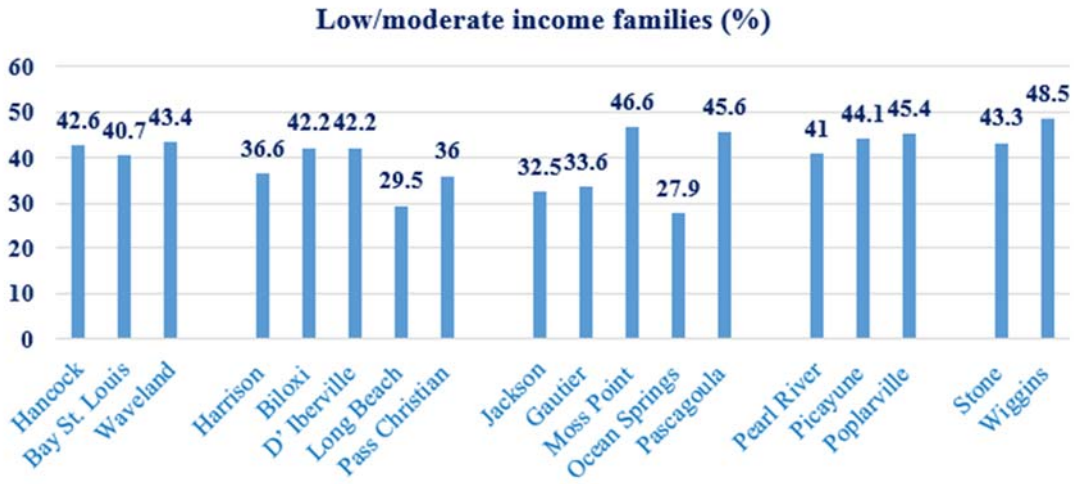

Figure 3. Percentage of low to moderate income families in the six coastal counties of Mississippi

2.3. Proposed area of study

Figure 4 shows the six priority watersheds of Mississippi coastal region. The wastewater effluent quality often exceeds the USEPA (United States Environmental Protection Agency) standards for the decentralized communities which may result in increased nutrient loads into receiving water body in the Jourdan river watershed. This watershed has been identified as a priority watershed due to its importance and the critical role it plays in maintaining the water quality of Bay St. Louis shoreline in the Gulf of Mexico [1].

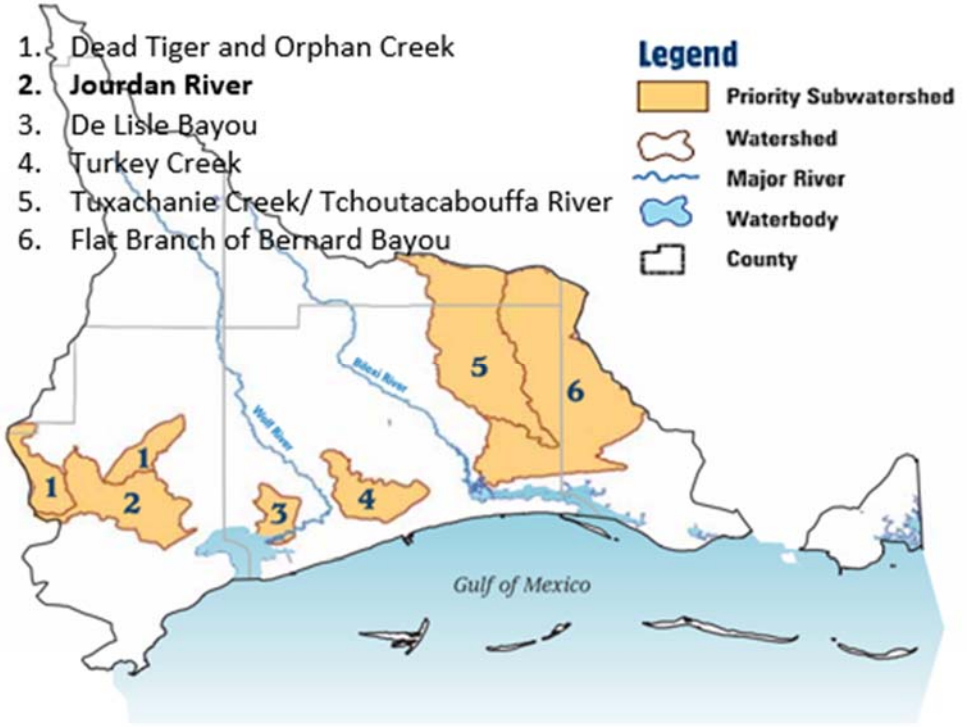

Figure 4. Priority watersheds in Mississippi coastal region – Jourdan River watershed is the focus area for this research [x]

About 11% of the surface waters in the coastal streams have received poor ratings (fair or poor). We will focus on communities in the Jourdan River watershed to evaluate the wastewater effluent quality from on-site disposal and its possible impacts on the receiving waters. The goal of this research is to evaluate the current methods and alternatives for on-site wastewater treatment and nutrient removal in decentralized communities in the Jourdan River watershed. Evaluations will focus on providing safe, effective and economic wastewater treatment for pathogen and nutrient control and identify nutrient management and water reuse opportunities. We propose to develop this knowledge based on the critical input from lessons learned from existing and previous case studies and experiences gained from the previous research efforts in this region. Water quality and facility maintenance data will be compiled and assessed to identify possible causes of on-site wastewater system failures. Sample collection and analysis will be performed for representative sites with diverse wastewater treatment systems to evaluate the system operational performance over a period of time.

2.4. Representative Communities

Assessment of water and wastewater is crucial to safeguard public health and the environment; however, water quality data on fresh and marine waters in the Mississippi coastal region, especially in the Jourdan River watershed are still sparse and uncoordinated. The lack of available data in the region of study proved problematic for the determination of representative communities. The most significant parameter when determining representative communities is treatment practices within the community. The lack of data made this extremely difficult. Therefore, location was used to ensure chosen communities would represent decentralized communities utilizing onsite treatment practices. Small communities and clusters of homes outside of established municipal service boundaries were researched to determine their treatment practices. Ultimately, seven representative sites were chosen in order to evaluate the effects decentralized onsite treatment practices may have on the watershed. These communities all lie within one-half mile of tributaries to the Jourdan River (**Figure 5**).

2.5. Sampling Sites

Rather than sampling from individual treatment systems within the representative communities, samples will be collected at upstream and downstream locations for each of the seven representative communities in order to analyze the effects of the community as a whole on the water quality of the Jourdan River watershed. Points of public access were chosen for sampling sites, limiting the number of possible sites to choose from. With this restriction, some sampling locations are located further downstream from the representative community than is ideal. Under these circumstances, land use surrounding the communities will be heavily considered to separate any other factors that may cause a change in water quality between upstream and downstream sampling locations.

3. Results and Discussion

While the extent of their effect on the water quality in the Jourdan River watershed is not yet clear, it is evident the current wastewater treatment and nutrient removal methods in these communities have some impact. The ultimate goal of this project is to determine the specific needs of these communities in order to recommend the appropriate technologies for the area. While the treatment technologies implemented in the area are able to provide sufficient wastewater treatment under certain conditions, many of these treatment units are not operating under these specific conditions. Very few, if any, areas where these systems are being used have the soil type necessary to provide adequate treatment [4]. Of the six Mississippi coastal communities, Hancock County has the lowest relative soil suitability at only 8%, as well as the highest percentage of onsite treatment systems operating passed failure [6]. Existing alternative systems able to overcome this issue are often more expensive than the conventional systems and require

more routine maintenance. These social and economic characteristics have led to negative public perception of these advanced systems.

Members of communities which lie outside of established municipal sewer service boundaries are required to use decentralized systems and would prefer systems with few maintenance requirements. Systems requiring a higher degree of maintenance also require users to have a better understanding of the systems in place. Often, this requirement mandates professional maintenance rather than owner maintenance, which leads to increased operational costs. Additional costs are also encountered during system installation. Alternative systems offer a higher level of treatment, but they do so at a higher cost. These are important considerations when suggesting or developing alternative onsite wastewater treatment systems for the communities.

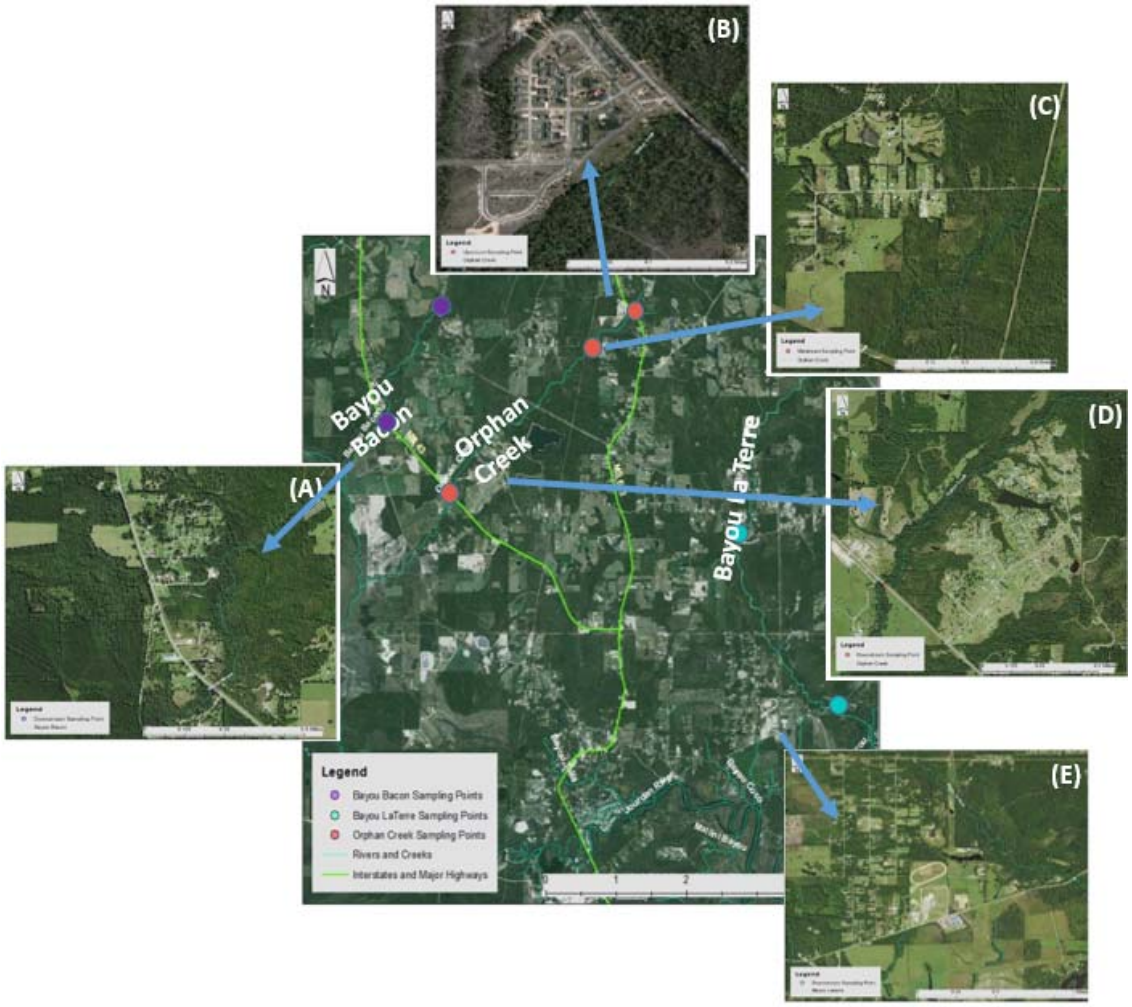

Figure 5. Representative sampling sites: (A) Bayou Bacon downstream community; (B) Orphan Creek upstream community; (C) Orphan Creek midstream community; (D) Orphan Creek downstream community; (E) Bayou La Terre downstream community in Jourdan River Watershed

3.1. Potential onsite treatment system configurations

Sequential nitrification/denitrification processes, which attempt to optimize natural biological processes through engineering, form the basis of essentially all biological N removal technologies that are currently

being used in wastewater treatment (**Figure 6**) [8]. Aerobic processes are first used to remove carbonaceous biochemical oxygen demand (CBOD) and nitrify NH_4^+-N. Anoxic processes then reduce NO_3^--N to N_2 gas, either using the wastewater or bacterial cells as a carbon source, or an external carbon source such as woodchips. Although there are other biological and non-biological processes that have been used, biological nitrification/ denitrification is the principal process that has been demonstrated to be feasible, both economically and technically, for nitrogen removal in both centralized and decentralized systems.

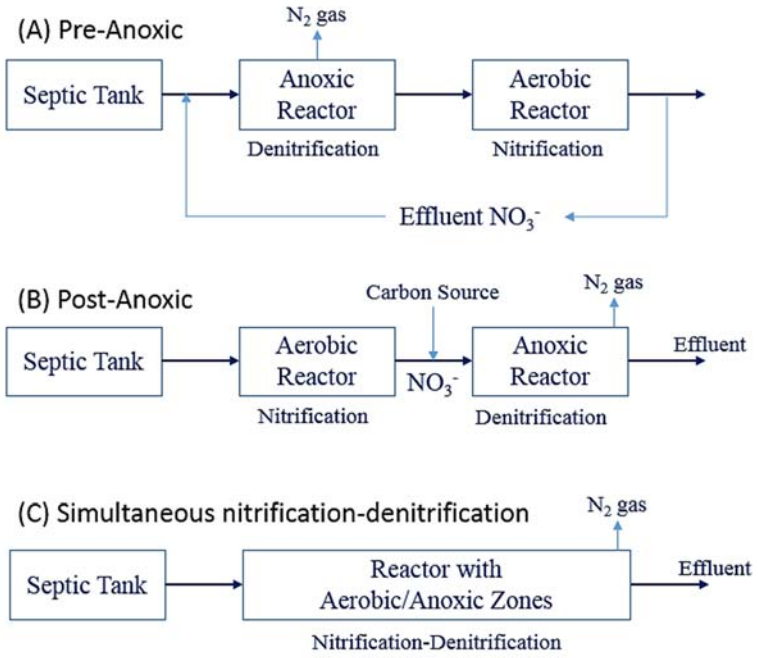

Figure 6. Schematic of pre-anoxic and post-anoxic, and simultaneous nitrification/denitrification processes.

Illustrations of N removal process configurations -There are three common N removal process configurations used in centralized wastewater treatment plants and OWTs: pre-anoxic, post-anoxic, and simultaneous nitrification–denitrification. In pre-anoxic systems a denitrifying anoxic tank using the wastewater as the carbon source precedes the aeration tank where nitrification occurs, and the nitrified effluent from the aeration tank is recycled back to the influent side of the anoxic tank; this is the most common configuration used in municipal wastewater treatment and is very commonly used in OWTs. In post-anoxic systems, the denitrifying anoxic reactor follows the aeration tank and the carbon source can come from either endogenous respiration of bacterial cells or an external source, methanol is the most commonly used external carbon source in centralized plants, and acetate, ethanol, and wood chips have been used in OWTs. In simultaneous systems, both nitrification and denitrification occur in the same reactor. Simultaneous configurations are most often used in suspended-growth designs, and pre-anoxic and post-anoxic are most commonly in attached-growth or combinations of suspended/attached-growth.

4. **Conclusions**

Coastal Mississippi water quality issues are not only related to outdated or inefficient onsite wastewater treatment systems but also include challenges in educating the public about and enforcement of pollution control regulations, and inadequate or poorly maintained stormwater infrastructure. Sewage treatment facilities in centralized systems have gone without crucial upgrades, allowing untreated sewage to pollute our waterways. Ineffective treatment facilities limit the community's ability to grow.

Recommended strategies and/or best practices for improving the water quality should include the following [7].

- Assist high growth areas with transition from septic systems to centralized waste treatment systems
- Provide technical assistance to property owners and developers regarding conservation practices to improve nutrient and sediment management
- Upgrade existing wastewater treatment plants to reduce pollutant loading
- Develop mechanisms (policy and technology) that reduce nutrient loadings from residential and commercial developments
- Support monitoring and enforcement programs that resolve water quality violations;

Beyond wastewater treatment and management, the efforts should expand into conserving and managing floodplain and riparian wetlands for stormwater management. Investing in green infrastructure for stormwater management, such as bioswales and permeable pavement will help reduce the non-point source pollutants.

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