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ASSESSMENT OF GROUNDWATER QUALITY AFFECTED BY RICE MILL SOLID WASTE IN TARKA, BENUE STATE

Terwase Emmanuel Terkimbi and Ihyembe Grace Dooshima
Department of Agricultural Technology, Federal Polytechnic Wannune, Benue State, Nigeria
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Abstract: Laboratory and field experiments were carried out during dry season of 2025 to determine the influence of rice mill solid waste on groundwater chemical composition at various locations (Uchi, Wannune and Tarhembe) in Tarka local Government Area of Benue State. Well water samples were collected from fifteen (15) open wells, five (5) from each location during the dry season of 2025 within a distance of 1km from the rice mill solid waste dumpsites and analysed for the following parameters: Temperature (oC), Turbidity(mg/L), pH, EC (ds/m), Alkalinity (mg/L), Hardness (mg/L), Chlorine (mg/L), Fe (mg/L), Acidity (mg/L), DO (mg/L), COD (mg/L), BOD (mg/L), Sulphate (mg/L), Nitrate (mg/L), Phosphate (mg/L) and selected Heavy Metals (Cd, Pb, Cr, Zn and Mn). The results indicated that the parameters examined in the groundwater samples in all locations showed a decrease in concentration with distances away from the dumpsites, except Fe and Al. Heavy Metal concentration in water at these locations was below permissible safe limits, except in soils of Tarhembe rice mill where Cd (0.06) was slightly above these limits. It was concluded that rice mill solid waste significantly influenced various measurable ground water properties. Continuous monitoring of these quality indices would be required to avoid contamination of the ground water sources within the vicinity of the dumpsites.

Keywords: solid waste, dumpsite, permissible, concentration, parameters.

INTRODUCTION

Water is indispensable and one of the precious natural resources of our planet. Ground water is an important natural source of water supply all over the world. Its use in irrigation, industries and domestic usage continues to increase where perennial surface water source is absent. The modern civilizations, over exploitations, rapid industrialization and increased population have led to fast degradation of our environment. To meet the rising demand, it is imperative to recognize the fresh water resources and also to find out remedial methods for improvement of water quality. The quality of groundwater may depend on geology of particular area and also vary with depth of water table and seasonal changes and is governed by the extent and composition of dissolved salts depending upon the source of the salt and soil subsurface environment. Water intended for human consumption should be safe and wholesome that is free from pathogenic agent and harmful chemicals, pleasant to taste and useable for domestic purpose. In the context of quality and quantity, groundwater fluctuates invariably in its own which reflects the time to time status of groundwater as a whole for a region, (Awodun et al., 2007)

Industrial activity affects the environment directly or indirectly. Environmental emission from any industry has impact on air, water and land. It is very much necessary to increase awareness of the fact that clean environment is necessary for smooth living and better health of human beings. Primary milling of rice is the most important activity in food grain production. Due to industrialization and global competitive market trends, it has emerged as major industrial activity in small to medium sector to cater the needs of increasing population. There are huge number of mills engaged in processing of rice and are spread over in almost all state across the country due to increasing trends. Rice milling is the process of removing the husk and part of the bran from paddy in order to produce the rice for eating. Parboiled rice production generally requires huge amount of water for soaking of the paddy. Waste water coming from rice mill operations contains high concentration of organic and inorganic substance causing significant polluting phenomena. The present study aims at understanding the extent of water pollution due to the effluents from rice mill. Water is a common liquid necessary to living things for diverse uses and activities which include drinking, cooking, industrial processes, agricultural uses, waste disposal and human recreation. The standard of water depends on the origin of territory and the action of man, including the usage. Furthermore, the advantageous properties of water standard include, sufficient volume of disintegrated oxygen at all time, a comparatively small organic matter, pH importance near neutrality, average temperature, and independence from immoderate quality contiguous agents, poisonous materials, and mineral occurrence and free of heavy metals. So many circumstances are accountable for water impurity and which makes it quite unwanted for portability. This has being the case in most towns of Benue State. In Uchi, Wannune and Tarhembe towns of Benue, milling of rice commenced in little quantities manually in the late '70s. by the middle of the nineties to date, the rice milling industry has blossomed and has become the major source of income for a large number of households with its attendant effect on waste generation and environmental quality. There are factors that affect water quality which include; sewage release, and this supply to oxygen demand and nutrient loading to undermine aquatic ecosystem (Sharma and Reddy, 2004), industrialization and agricultural practices. Pollution simply emerges when society development out matches availability of good water due to insufficient urban disposition procedure.

Commercial rice milling activities commenced in the early eighties in Benue State and the volume of activity in this industry has progressively increased over time. As a consequence, large volumes of rice mill solid waste are disposed on the surface of the soil in most areas where rice milling is carried out. The practice at the Uchi, Wannune and Tarhembe rice mills is not different. The rice husk waste that is generated can be harmful to the environment. These wastes often contain a considerable amount of toxic compound and metals, which always contaminates the soil and water. The rice husk dust poses a serious risk to ground water contamination due to surface runoff and can lead to ground and surface water contamination (Olatunji and Ayuba 2011). The high nutrient content in rice husk suspended and dissolved in water can deplete dissolved oxygen in the water which can lead to the death of aquatic organisms (United State Environmental Protection Agency, 1999).

These wastes which are dumped on the surface of the soil, apart from being an eye sore pollute the soil, ultimately affecting human health. The decomposing solid wastes in soils also produce toxic vapors (Uguru et al., 2015). The husk is disposed, on open land very close to the milling centre. These over grown heaps of rice waste cause environmental nuisance and contribute to the loss of nutrients to runoff water, thus reducing the soil quality since these soil nutrients are not recycled. Most millers do not know how to dispose these wastes apart from using these wastes to liter the nearby environment (Mbah, 2006).

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In spite of the magnitude of these wastes which are generated on daily basis and their possible adverse effects on the environment such as pollution, till today no serious attempt has been made either for their effective utilization or safe disposal (Nnabude and Mbagwu 2001).

This study was therefore carried out to evaluate effect of rice mill solid waste on groundwater chemical composition in the areas under investigation,

MATERIALS AND METHODS

Groundwater samples were collected from fifteen (15) open wells, five (5) from each rice mill dumpsite at various locations (Uchi, Wannune and Tarhembe) during the dry season of 2025 within 1km from the rice mill dumpsites and analyzed for temperature, pH, iron, alkalinity, hardness, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chloride, acidity, nitrates, sulphate, phosphates. Data generated was compared with the standards for drinking water by WHO (2004).

Concentration of heavy metals in the water samples (lead, cadmium, zinc and Manganese) were determined using atomic absorption spectrophotometer (AAS). Data generated was compared with the WHO safety limits for metals in drinking water.

Table 1: Safety Limit of Heavy Metal Concentration (mgkg^{-1}) in Soil

S/No.	Metal	Concentration
	Fe Cu	
		100
	Zn	300
	Mn	2000
	Ni	50
	Cr	100
	Cd	3.0
	Pb	100

Source: Al-Jaboobi (2014).

Table 2: Safety Limit of Heavy Metal Concentration (mgL^{-1}) in Water Samples

S/No.	Metal	Concentration
	Fe	5.0
	Cu	0.2
	Zn	2.0
	Mn	0.2
	Ni	0.2
	Cr	0.1
	Cd	0.01
	Pb	5.0

Source: Al-Jaboobi (2014

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RESULTS 4.1: Chemical Composition of Ground Water across the Experimental locations during the 2025 Dry Season

Chemical composition of ground water around the three rice mills is presented on Table 3. The highest water temperature of 29.10^{o}c was recorded in surface water sources around Uchi this was followed by Wannune rice mill with 28.00^{o}C and the least temperature value of 26.70^{o}C was recorded at Tarhembe rice mill. Turbidity value was highest in Tarhembe rice mill with 23.20mgl^1 followed by 28mgl^{-1} in Wannune and the least value of 15.03mgl^{-1} found in Uchi rice mill. The water pH values of water ranged from 6.84 at Wannune, 6.73 at Tarhembe and 6.36 at Uchi. Electrical conductivity values varied from 0.09dsm^{-1}Aliade, 0.06dsm^{-1}at Tarhembe and 0.05dsm^{-1} at Wannune. Alkalinity ranged from 47.37mgl^{-1} at Tarhembe, 36.66mgl^{-1} at Uchi and 33.44mgl^1 in Wannune. Mean values for hardness were 36.76, 30.80 and 24.60 m gl^{-1} for Tarhembe, Uchi and Wannune rice mills respectively. Chlorine content was highest 2.20 mgl^{-1} at Wannune. This was followed by 1.55mgl^{-1} at Uchi while the least value of 1.48mgl^{-1} was obtained at Tarhembe. Iron (Fe) content was highest at Aliade 1.35 mgl^{-1}. This was followed by Wannune 1.10 mgl^{-1} and 0.98 mgl^{-1} at Tarhembe. Dissolved oxygen content was highest at Uchi 6.36 mgl^{-1} followed by Wannune 6.30mgl^{-1} and least value of 5.50mgl^{-1} was obtained at Tarhembe. Acidity of water was highest at Tarhembe 27.20 mgl^{-1}, Uchi had 22.40mgl^{-1} and the least value of 21.60mgl^{-1} was obtained at Wannune rice mill. The chemical oxygen demand was 711.80mgl^{-1} at Tarhembe rice mill, 405.40mgl^{-1} at Uchi and 292.00mgl^{-1} in Wannune. Biological oxygen demand values for groundwater at the rice mills was 509.80 mgl^{-1} for Tarhembe, 375.20 mgl^{-1} for Uchi and the least value of 352.00 mgl^{-1} was obtained in Wannune. Concentration of Sulphate in the water around the rice mills varied from 0.64mgl^{-1} at Wannune, 0.36mgl^{-1} at Uchi and 0.12mgl^{-1} at the Tarhembe rice mill.

Nitrate concentration in the groundwater sample around the rice mills was 0.01mgl^{-1} in all the locations. Mean Phosphate concentration in groundwater sample during the 2025 dry season indicates that the highest concentration of 2.48mgl^{-1} was at the Uchi rice mill. This was followed by 2.47mgl^{-1} at Wannune and the least value of 1.84mgl^{-1} was obtained at the Tarhembe rice mill.

4.2: Mean Concentration of Heavy metals in the Ground Water samples across the Experimental locations during the 2025 Dry Season.

Mean concentration of selected heavy metals in the ground water samples around the experimental location are presented on Table 19. The highest value of Cd was found to be 0.03mgl^{-1} in Wannune while the value of 0.02mgl^{-1} was obtained with the ground water sample at Uchi and 0.01mgl^{-1} from Tarhembe. Pb had the highest values of 0.18mgl^{-1} at Tarhembe and was followed by 0.15mgl^1 from Uchi with 0.14mgl^{-1} from Wannune rice mill. Cr had the highest value of 0.08mgl^{-1} at Uchi followed by 0.07mgl^{-1} from Tarhembe rice mill and 0.06mgl^{-1} was obtained from Wannune. The value of 0.11mgl^{-1} was obtained for Mn with sample at Uchi rice mill while 0.10mgl^{-1} was obtained with samples from Wannune and 0.08mgl^{-1} at Tarhembe rice mill. Concentration of Zn in the ground water samples was highest at Uchi with 0.23mgl^{-1} this was followed by 0.21mgl^{-1} for ground water sample obtained in Wannune rice mill with 0.20mgl^{-1} at Tarhembe rice waste dumpsite.

DISCUSSION

Water is one of the most indispensable resources and is the elixir of life. It constitutes about 70% of the body weight of almost all living organisms. Life is not possible on this planet without water. It acts as a media for both chemical and biochemical reactions and also serves as an internal and external medium for several organisms (Rajankar et al. 2009). Additionally, basic functions of a society require water;

for cleaning, for public health consumption, for industrial processes and cooling for electricity generation.

Ground water constitutes 20% of water present as freshwater. The value of groundwater lies not only in its wide spread occurrence and availability but also in it's consistent good quality, which makes it an ideal supply for drinking water (UNESCO, 2000). However, ground water resources are under a serious threat due to growing interest in mechanized agricultural practices, increasing population density and rapid urbanization as well as domestic and industrial usage. Ground water provisions are sometimes unsustainable because of poor water productivity of wells, drying of wells after prolonged drought and sometimes due to poor water quality (Kortatsi, 1994; Xu and Usher, 2006).

Generally, the pH values across the locations were higher during the dry season. Lower pH values during the wet season could probably be ascribed to increased precipitation resulting into dissolution of acid forming substances which could include gases given off as a result of a favorable environment for decomposition. Dissolution of components of the parent's material which may be acid forming could also be responsible for this. Acidity in all the locations also increased with increasing distance away from the dumpsite. Decrease in volume of the rice mill solid waste with distance away from the dumpsite could be responsible for this trend as the organic solid waste could have buffered the soils where the waste are more abundant.

Decomposition of products of the solid waste which could have been basic in nature could have probably neutralized this acidity. Increasingly acidity with distance away from the dumpsite implies that nutrient availability would also decrease with distance away from the dumpsite. Evidence that pH exerts the greatest general influence on plant growth through it effect on nutrient availability had earlier been reported by Foth (1990). Generally, micro nutrient and perhaps heavy metal availability increases with decreasing pH thus concentration of these metals would likely increase with distance away from the dumpsite. Interestingly, organic carbon, Nitrogen, Phosphorus and Sulphur content in all the locations decreased with distance away from the dumpsite. The cation exchange capacity of the experimental location also followed the same trend. Foth (1990) had earlier reported that the most favorable range for Nitrogen availability is between 6 and 8, because this is the most favorable range for the soil microbes that mineralize the nitrogen in organic matter and those organisms that fix nitrogen symbiotically. Maximum Phosphorus availability has also been reported to be in the range of pH 7.5 to 6.5. As soil acidity increases, those nutrients show less availability as a result of decreasing CEC and decreased amounts of exchangeable nutrient cations. This trend is observed in all the locations studied. On the contrary, concentration of Fe and Al increased with distance away from the dumpsite. Evidence that Iron and Manganese availability increase with increasing acidity because of their increase solubility had earlier been reported by Foth (1990). This was the case in the instant study.

Anjembe et al. (2018) defined heavy metals as metallic elements with an atomic weight greater than that of iron ($55.5gmol^{-1}$) or density greater than $5.0gcm^{3}$. They are present at relatively low concentration in soils, plants and natural water. Rakshit et al. (2017) stated that heavy metals are a consortium of transition metals, metalloids, lanthanides and actinides having the density of $5.0\ Mgm^{-3}$ or more and atomic weight more than that of Calcium. They occur naturally in several rock constituting minerals. However, when concentrations are raised above permissible limits due to anthropogenic or geogenic activities the heavy metal pollution occurs. In the present study, concentration of these metals decreased with distance away from the dumpsite. This is consistent with the findings of Rakshit et al. (2015) who reported that the sources of heavy metal pollution amongst others are waste disposal. In the present study, continuous disposal of rice mill solid waste could have probably introduced these metals to the soils. Decreasing concentration of these metals with distance away from the dumpsite further supports this assertion. Their concentration in the soils however is within the safety limits. Turbidity values for dry season was higher in Tarhembe. This can be attributed to the volume of activities taking place at the rice mill as the Tarhembe rice mill appears to be the biggest amongst the three. The least values were obtained at the Uchi rice mill which was the smallest amongst the three.

The implication of this is that volume of rice milling activity would have made the water bodies around the rice mill more turbid.

The relationship between pH and some quality defining parameters in water indicates that pH exerts a profound influence on organic matter accumulation. Acidic soils are likely to favour decomposition of organic matter. P content of soils will decrease as acidity increase. The fact that pH exerts a great influence on P availability is well established. Fe and Al related negatively but highly significantly indicating the availability of Fe and Al in acidic soil. Similar relationships have earlier been reported by Adepetu, et al. (2016). Relationships between organic carbons derived from the rice mill solid waste with Zn and Pb was positive and significant. Increased levels of these heavy metals in the soils of the rice mill as well as Pb again showed a negatively but highly significant relationship indicating that the concentration of the heavy metals in soil will increase with decreasing Al and Fe content. The implication is that as the pH of the soil decrease or as the soil becomes more acidic, concentration of Pb would decrease. Similar trends were observed with soils of the Aliade and Makurdi rice mills. However, the positive relationship between Mn and Cr indicated that Cr content would increase with increasing acidity but decrease as the pH would increase. Cr thus conveniently behaved like a micronutrient in this soil. Mn and Zn, all of which are micronutrients behaved and associated positively with chromium. The soil properties showed no significant relationship with any of the heavy metals in groundwater indicating that the status of the metal in groundwater could thus be attributed to the parent material. However Phosphate content of groundwater would decrease as D.O increase. The implication is that Dissolved oxygen would oxidize organic pollutants present in groundwater in all the locations. Generally, the concentrations of the parameters examined in all locations under investigation in this study are within permissible levels. It was thus concluded from the foregoing that; rice mill solid waste significantly influenced various measurable ground water properties in all the experimental locations.

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