on changes in nitrate concentration with a significance value of p <0.05. The effect of processing time on changes in nitrate concentration has a significance value of p <0.05, so processing time has a significant effect.

F. Changes in pH at various pellet doses in goat urine processing into N fertilizer.

One of the factors that influence the nitrification process is the pH value. The optimum pH value for the nitrification process is between 7.5-8.5 [22]. Nitrifying bacteria are very sensitive to pH values. At pH 6.3 - 6.7, the nitrification process will slow down, then at pH 5 - 5.5 the nitrification process will stop. No change in ammonium, nitrite, and nitrate concentrations at pH 5 is noticeable, which indicated a strong inhibition of ammonium oxidation at pH 5 [23]. The results of pH measurements during the processing of goat urine into N fertilizer are presented in Fig. 5.

In Fig. 6, it can be seen that the pH value of the three samples with a pellet dose of 10% (w/v), 20% (w/v), and 30% (w/v) has decreased over time. The treatment hours resemble the stages of the nitrification process. The pH value decreases in the first hour as the ammonia concentration decreases. In addition to producing NO_2^- ions, the nitrification reaction in the nitritation stage will also release H^+ and H_2O ions. This H^+ ion causes a decrease in pH. This is because H^+ ions are acidic so that the pH value decreases [24].

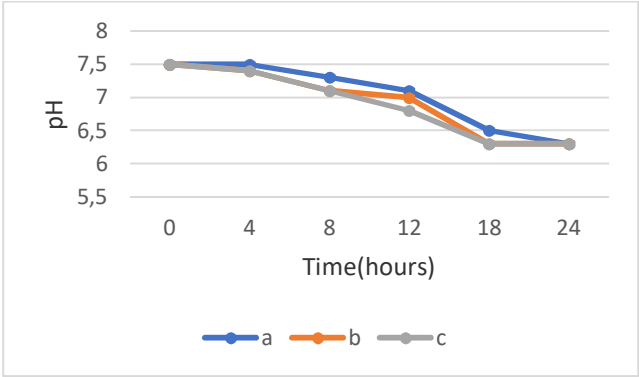

Fig. 6 pH changes during nitrification

If the ammonia increases, the pH value will also substantially increase. At pH 7 or less, most of the ammonia will be ionized and vice versa at a pH greater than 7, ammonia is not ionized and is toxic, and the amount is more. The pH value can also decrease if there is a process of nitrite and nitrate formation [25], with the following reactions:

$$NH4+ + 3/2\ O2 \rightarrow NO2- + 2H+ + H2O \quad (1)$$

$$NO2- + ½\ O2 \rightarrow NO3- \quad (2)$$

The above reaction shows that each mole of ammonium is oxidized to produce 2 moles of hydrogen ions, which results in a lower pH value. This shows that nitrifying bacteria are very sensitive to pH values. The decrease in pH value is also caused by the presence of carbon dioxide (CO_2), which is produced from the process of breaking down urea in water contained in goat urine with the help of the urease enzyme, which is owned by nitrifying bacteria, with the following reaction:

$$CO(NH2)2 + H2O \rightarrow 2\ NH3 + CO2 \quad (3)$$

Carbon dioxide will react with water molecules to form carbonic acid and produce hydrogen ions in the goat urine sample to be acidic. The reactions that occur is [26] :

$$CO2 + H2O \rightarrow HCO3- + H+ \quad (4)$$

The solubility of carbon dioxide in the water contained in goat urine can be affected by temperature. The increase in temperature will cause CO_2 gas to come out of urine, so that the increase in temperature will cause the CO_2 level to be lower. Conversely, the lower the temperature, the more CO_2 will dissolve and increase the hydrogen level in the urine so that the urine will have an acidic pH. The pH value decreases over time, so it can be said that the longer the nitrification process is less optimal because the optimal pH of the nitrification process is at pH 7.5 - 8.5. The decrease in the pH value at each pellet dose in the data above does not reach pH 5 so that the nitrification process has not been stopped. It is just that the ongoing process has decreased effectiveness and the result of ammonia oxidation is not optimal at too low a pH. Low pH has an inhibition effect on ammonia-oxidizing bacteria [27].

The lowest average pH value for samples with a pellet dose of 10% (w/v) and 20% (w/v) is 6.6 at the 24th-hour measurement, while for samples with a pellet dose of 30% (w/v)) the lowest average pH value reaches 6.4 which means that the nitrification process can still take place and has not stopped, but its effectiveness has decreased. If the pH is less than 6.4, there will be no growth of autotrophic bacteria (nitrifying bacteria) [28].

IV. Conclusion

According to the explanation above, it can be concluded that the best medium for ammonia oxidizers pellets to undergo nitrification process for goat urine treatment is Ammonia Oxidizer Media II (media for pellet b) which was built of 10 grams of NPK fertilizer, 10 grams of glucose, and 5 grams of NH_4Cl powder. Then, the dosage B in tube 2, which contained pellets of 20% (w/v) (pellet b) consisted of 100 grams of pellets in 500 mL of goat's urine, was the best dosage that was shown to effectively reduce ammonia, increase nitrate levels and reduce nitrite levels and the ability to withstand neutral pH for up to 18 hours. Finally, amongst all pellets' dosages, the highest nitrite removal was performed by the sample with a pellet dose of 20% (w/v) (pellet b) and the measurement time at 18 hours, with an average nitrite concentration of three repetitions of 2.3992 mg/L. This research has successfully addressed the correlation between the performance of local-materials-based pellets to undergo nitrification and the impact of pH level on nitrification. However, there is still a gap in this research that has not been observed profoundly, namely the impact of the other environmental factors such as temperature, dissolved oxygen, alkalinity, and organic matter degradation on the nitrification process using pellets.

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REFERENCES

[1] Y. Hu, H. Cheng, and S. Tao, "Environmental and human health challenges of industrial livestock and poultry farming in China and their mitigation," *Environment International*. 2017, doi: 10.1016/j.envint.2017.07.003.

[2] J. Lv, Y. Liu, J. Feng, Q. Liu, F. Nan, and S. Xie, "Nutrients removal from undiluted cattle farm wastewater by the two-stage process of microalgae-based wastewater treatment," *Bioresour. Technol.*, 2018, doi: 10.1016/j.biortech.2018.05.085.

[3] K. H. Cho, J. O. Kim, S. Kang, H. Park, S. Kim, and Y. M. Kim, "Achieving enhanced nitrification in communities of nitrifying bacteria in full-scale wastewater treatment plants via optimal temperature and pH," *Sep. Purif. Technol.*, 2014, doi: 10.1016/j.seppur.2014.06.027.

[4] L. Wang *et al.*, "Response Characteristics of Nitrifying Bacteria and Archaea Community Involved in Nitrogen Removal and Bioelectricity Generation in Integrated Tidal Flow Constructed Wetland-Microbial Fuel Cell," *Front. Microbiol.*, 2020, doi: 10.3389/fmicb.2020.01385.

[5] Y. Zhang *et al.*, "Association of robust nitrogen removal with spatiotemporal nitrifying bacterial community dynamics in a new bioreactor for treatment of simulated livestock wastewater with high ammonia content," *J. Chem. Technol. Biotechnol.*, 2019, doi: 10.1002/jctb.5809.

[6] M. B. Vanotti and P. G. Hunt, "Nitrification treatment of swine wastewater with acclimated nitrifying sludge immobilized in polymer pelletsVanotti, M. B., & Hunt, P. G. (2000). Nitrification treatment of swine wastewater with acclimated nitrifying sludge immobilized in polymer pellets.," *Trans. Am. Soc. Agric. Eng.*, 2000, doi: 10.13031/2013.2719.

[7] I. G. A. L. Pradnyadari, I. W. B. Suyasa, and N. G. A. M. D. A. Suastuti, "Penyisihan Amonia, Nitrit Dan Nitrat Dengan Biofilter Menggunakan Plastik Bekas Sebagai Media Penopang Biofilm," *J. Media Sains*, 2018.

[8] N. Sudaryati, I. Kasa, and I. Budiarsa Suyasa, "Pemanfaatan Sedimen Perairan Tercemar Sebagai Bahan Lumpur Aktif Dalam Pengolahan Limbah Cair Industri Tahu," *Ecotrophic J. Environ. Sci.*, 2012.

[9] S. Huang *et al.*, "Effects of low-intensity ultrasound on nitrite accumulation and microbial characteristics during partial nitrification," *Sci. Total Environ.*, 2020, doi: 10.1016/j.scitotenv.2019.135985.

[10] X. Zheng *et al.*, "Inhibition of free ammonia to the granule-based enhanced biological phosphorus removal system and the recoverability," *Bioresour. Technol.*, 2013, doi: 10.1016/j.biortech.2013.08.100.

[11] I. Obernberger and G. Thek, "Physical characterisation and chemical composition of densified biomass fuels with regard to their combustion behaviour," *Biomass and Bioenergy*, 2004, doi: 10.1016/j.biombioe.2003.07.006.

[12] R. Labbé, S. Paczkowski, V. Knappe, M. Russ, M. Wöhler, and S. Pelz, "Effect of feedstock particle size distribution and feedstock moisture content on pellet production efficiency, pellet quality, transport and combustion emissions," *Fuel*, 2020, doi: 10.1016/j.fuel.2019.116662.

[13] R. Cáceres, K. Malińska, and O. Marfà, "Nitrification within composting: A review," *Waste Management*. 2018, doi: 10.1016/j.wasman.2017.10.049.

[14] Z. Y. Sun, J. Zhang, X. Z. Zhong, L. Tan, Y. Q. Tang, and K. Kida, "Production of nitrate-rich compost from the solid fraction of dairy manure by a lab-scale composting system," *Waste Manag.*, 2016, doi: 10.1016/j.wasman.2016.03.002.

[15] N. Ungureanu, V. Vladut, G. Voicu, M. N. Dinca, and B. S. Zabava, "Influence of biomass moisture content on pellet properties - Review," 2018, doi: 10.22616/ERDev2018.17.N449.

[16] T. Allegue, A. Arias, N. Fernandez-Gonzalez, F. Omil, and J. M. Garrido, "Enrichment of nitrite-dependent anaerobic methane oxidizing bacteria in a membrane bioreactor," *Chem. Eng. J.*, 2018, doi: 10.1016/j.cej.2018.04.134.

[17] P. Han *et al.*, "N2O and NOy production by the comammox bacterium Nitrospira inopinata in comparison with canonical ammonia oxidizers," *Water Res.*, 2021, doi: 10.1016/j.watres.2020.116728.

[18] T. Hudakorn and N. Sritrakul, "Biogas and biomass pellet production from water hyacinth," 2020, doi: 10.1016/j.egyr.2019.11.115.

[19] A. A. Abdul-Rahman, N. Yusoff, and A. Abd-Rahman, "The effects of biomass binders and moisture content on the mechanical durability of rice husk pellets," 2020, doi: 10.1088/1757-899X/736/5/052013.

[20] M. Y. Patri, "Penentuan Kadar Ammonia (NH3) pada Limbah Cair K-36 dalam Rangka Pengendalian Pencemaran Lingkungan," *ALKIMIA J. Ilmu Kim. dan Terap.*, 2019, doi: 10.19109/alkimia.v2i2.2998.

[21] A. Sepehri and M.-H. Sarrafzadeh, "Activity enhancement of ammonia-oxidizing bacteria and nitrite-oxidizing bacteria in activated sludge process: metabolite reduction and CO2 mitigation intensification process," *Appl. Water Sci.*, 2019, doi: 10.1007/s13201-019-1017-6.

[22] F. Huang, L. Pan, N. Lv, and X. Tang, "Characterization of novel Bacillus strain N31 from mariculture water capable of halophilic heterotrophic nitrification–aerobic denitrification," *J. Biosci. Bioeng.*, 2017, doi: 10.1016/j.jbiosc.2017.06.008.

[23] T. T. H. Le, J. Fettig, and G. Meon, "Kinetics and simulation of nitrification at various pH values of a polluted river in the tropics," *Ecohydrol. Hydrobiol.*, 2019, doi: 10.1016/j.ecohyd.2018.06.006.

[24] E. Hopkins, T. Sanvictores, and S. Sharma, "Physiology, Acid Base Balance," *Treasure Isl. StatPearls Publ.*, 2020.

[25] P. S. Romer Present, A. Zare, and R. C. Cohen, "The changing role of organic nitrates in the removal and transport of NO*x*," *Atmos. Chem. Phys.*, 2020, doi: 10.5194/acp-20-267-2020.

[26] S. K. Reddy and S. Balasubramanian, "Carbonic acid: Molecule, crystal and aqueous solution," *Chem. Commun.*, 2014, doi: 10.1039/c3cc45174g.

[27] Y. Zou, Z. Hu, J. Zhang, H. Xie, C. Guimbaud, and Y. Fang, "Effects of pH on nitrogen transformations in media-based aquaponics," *Bioresour. Technol.*, 2016, doi: 10.1016/j.biortech.2015.12.079.

[28] A. Anisa and W. Herumurti, "Pengolahan Limbah Domestik Menggunakan Moving Bed Biofilm Reactor (MBBR) dengan Proses Aerobik-Anoksik untuk Menurunkan Konsentrasi Senyawa Organik dan Nitrogen," *J. Tek. ITS*, 2017, doi: 10.12962/j23373539.v6i2.25166.