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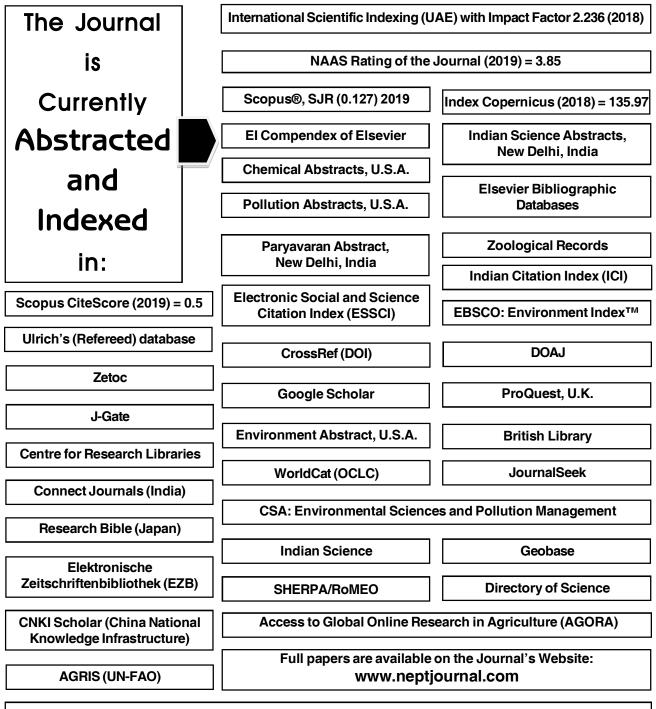
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CONTENTS

 Hasan F, Al-Rubai, Ahmed K, Hassan and Bahaa M, Attahir, The Kindic Model for Decoluurization of Commercial Direct Blue 2 Aco Dev Agueous Solution by the Ferton Process and the Effect of Ioneganic Salts V. M. Dikshit, Groundwater Recharge Potential Sites in Semi-Arid Region of Man River Basin, Maharashtra State, India: A Geoinformatic Approach Khan Ahmad Ali, Gouding Li and Wenchuan Wang, Comparative Study: The Adsorption Disparity for Tetracycline and Cefradine on Constatk Biochar I. P. Liang, Q. Wang, F. K. Xi, W. S. Tan, Y. T. Zhang, L. B. Cheng, Q. Wu, Y. Y. Xue and X. Meng, Effective Removal of Cr(VI) from Aqueous Solution Using Modified Orange Peel Powder: Equilibrium and Kinetic Study Topographical Factors in the Urbanized Ecosystem in Beijing. China: Reena Ahuja and Navat Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater Arrunugam, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling Using Visual Modflow in Timpur Region, Tamihadu, India Q. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Descritication in the Source Region of the Yellow River, China Measures on Soli Microbes and Enzymatic Activity Shihu Liu, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Study on the Efficionery of the Synchronous Alkal-ultrasonic Petraetarch of He Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digestion System Nur Ain Modd Nizam Prusbottman, Megat Ahmad Kamal Megat Hanaflah, Noorul Farhana M Ariff and Shariff Ibrahim, Edylenet Diandytamic (EDTAD) Modified Coconul Ford for Removal of PO(II) Ions: Kinetics, Isotherm and Thermodynamic Nur Ain Modd Nizam Prusbottman, Megat Ahmad Kamal Megat Hanaflah, Noorul Farhana M Ariff and Shariff Ibrahim, Edylenet Diandytanie (EDTAD) Modi	1.	M.E.M. Hassouna and M. H. Mahmoud, Realistic Decontamination of Fe ²⁺ Ions from Groundwater Using	
Commercial Direct Blue 2 Azo Dye Aqueous Solution by the Fenton Process and the Effect of Inorganic Salis 1355-1365 V. M. Dirkshit, Groundwater Recharge Potential Sites in Semi-Arid Region of Man River Basin, Maharashtra 1367-1378 Khan Ahmad Ali, Guoting Li and Wenchuan Wang, Comparative Study: The Adsorption Disparity for Tetracycline 1367-1378 K. Han Ahmad Ali, Guoting Li and Wenchuan Wang, Comparative Study: The Adsorption Disparity for Tetracycline 1397-1300 Topographical Factors in the Urbanized Ecosystem in Beijning, China 1391-1398 Topographical Factors in the Urbanized Ecosystem in Beijning, China 1391-1410 Reema Ahuja and Naval Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater 1411-1421 K. Arumugan, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling 1423-1433 U. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region of the Yellow River, China 1423-1432 Binglin Huang, Mengxue Wang, Xinjun Jin, Yuxian Zhang and Guohua Hu. Effects of Different Tillage 1435-1463 Measures on Soil Microbes and Enzymatic Activity 1435-1463 Nu Y. Ain Modu Nizam Prushotman, Megat Ahmad Kamal Megat Hanaffah, Noorul Farhana MA Afff and Sharff Ibrahim, Ehylenediamineterraacetic Dianhydride (EDTAD) Modified Cocourt Fond for Removal of Pb(II) 1453-1463		Bentonite/Chitosan Composite Fixed Bed Column Studies	1343-1354
 V. M. Dikshit, Groundwater Recharge Potential Sites in Semi-Arid Region of Man River Basin, Maharashtra State, India: A Geoinformatic Approach Khan Ahmad Ali, Guoting Li and Wenchuan Wang, Comparative Study: The Adsorption Disparity for Tetracycline and Cefradine on Comstalk Biochar L. P. Liang, Q. Wang, F. Xi, W. S. Tan, Y. T. Zhang, L. B. Cheng, Q. Wu, Y. Y. Xue and X. Meng, Effective Removal of Cr(VI) from Aqueous Solution Using Modified Orange Peel Powder: Equilibrium and Kinetic Study Haiying Peng and Haixia Peng, Correlation Analysis Between PM_{2-C} Concentration and Meteorological, Vegetation and Topographical Factors in the Urbanized Ecosystem in Beijing, China Reema Ahuja and Naval Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater K. Arumugam, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashihi, Groundwater Modelling Using Visual Modflow in Timpur Region, Tamilinadu, India Q. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Descrification in the Source Region of the Yellow River, China Shihu Liu, Lie He, Pengeheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Study on the Efficiency of the Synchronous Alkali-atlmasonic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anarobic Digestion System Nur Ain Mohd Nizam Prushotman, Megat Ahmad Kamal Megat Hanafiah, Noorul Farhana Md Ariff and Shariff Brahim, Ehylenediaminettraacetic Dianhydride (EDTAD) Modified Cocourt Fond for Removal of PK(II) Ions: Kinetix, Isotherm and Thermodynamic Yue (He, Zheng Li and Dingqian Jing, Evaluation of Health Level of Land-use Ecosystem Based on GIS Grid Model J.O. Olovyo, L. Mpagane and S. Nyikash Matter Matter Sludge and its Influence on the Microbial Population of the Green Polyscens for Polytone	2.	Hasan F. Al-Rubai, Ahmed K. Hassan and Bahaa M. Altahir, The Kinetic Model for Decolourization of	
State, India: A Geoinformatic Approach 1367-1378 4. Khan Ahmad Ali, Gouding Li and Wenchuan Wang, Comparative Study: The Adsorption Disparity for Tetracycline 1379-1390 5. L. P. Liang, Q. Wang, F. Xi, W. S. Tan, Y. T. Zhang, L. B. Cheng, Q. Wu, Y. Y. Xue and X. Meng, 1379-1390 7. Le P. Liang, Q. Wang, F. Xi, W. S. Tan, Y. T. Zhang, L. B. Cheng, Q. Wu, Y. Y. Xue and X. Meng, 1379-1390 8. Halying Feng and Hatxia Feng, Correlation Analysis Between PM, Concentration and Meteorological, Vegetation and 1399-1410 7. Reena Ahuja and Naval Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh 1411-1421 8. K. Arumugam, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling 1423-1433 9. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region 143-1422 10. Shihu Liu, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Sudy on the Efficiency of the Synchronous Alkali-ultrasonic Pretreatment of the Low Organic Mater Sludge and its Influence on the Microbial Propulation in the Anaerobic Digestion System 1453-1463 11. Nur Ain Modu Nizam Prushotman, Megat Ahmad Kamal Megat Hanafiah, Noorul Farhana MA Arff and Shariff Ibrahim, Ebylenciamineteraacetic Dianhydride (EDTAD) Modified Coconut Fond for Removal of PMII) 1453-1463 13. Vu Chi Chang Lia and Dingqian Jing, Evaluation of Health Level of Land-use Ecosystem Based on GIS Grid 1457-1482 14. Kud		Commercial Direct Blue 2 Azo Dye Aqueous Solution by the Fenton Process and the Effect of Inorganic Salts	1355-1365
 Khan Ahmad Ali, Guoting Li and Wenchuan Wang, Comparative Study: The Adsorption Disparity for Tetracycline and Cefradine on Constalk Biochar L. P. Liang, Q. Wang, F. F. Xi, W. S. Tan, Y. T. Zhang, L. B. Cheng, Q. Wu, Y. X. Xue and X. Meng, Effective Removal of Cr(VI) from Aqueous Solution Using Modified Orange Peel Powder: Equilibrium and Kinetics Study Haiying Feng and Haixing Feng. Correlation Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater Reena AU Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater K. Arumugann, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling Using Visual Modflow in Tirrupur Region, Tamilnadu, India Q. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region of the Yellow River, China Shihu Liu, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jan Zhou, Study on the Efficiency of the Synchronous Alkai-ultrasonic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digestin System Nur Ain Mohd Nizam Prushotnan, Megat Ahmad Kamal Megat Hanafiah, Norul Farhana Md Ariff and Shariff Tharhim, Etylenediamineterhazetic Dianhydride (EDTAD) Modified Coconut Frond for Removal of Pb(I) lons: Kinetics, Isotherm and Thermodynamic Wei He, Zheng Li and Dingqian Jing. Evaluation of Health Level of Land-use Ecosystem Based on GIS Grid Model Mudra F-Khuda (Babu), Causes of Air Pollution in Bangladesh's Capital City and Its Impacts on Public Health 149:1497 Wedyan, G. Nassif, Basim, L. Wahab, Monnim, H. Al-Jiborai and Abdurahhman, B. Ali, Temporal and Spatial Analysis of Alpha and Betu Activity Concentration	3.	V. M. Dikshit, Groundwater Recharge Potential Sites in Semi-Arid Region of Man River Basin, Maharashtra	
 and Ceffadire on Comstalk Biochar L. P. Liang, Q. Wang, F. F. Xi, W. S. Tan, Y. T. Zhang, L. B. Cheng, Q. Wu, Y. Y. Xue and X. Meng, Effective Removal of Cr(VI) from Aqueous Solution Using Modified Orange Peel Powder: Equilibrium and Kinetic Study Haiying Feng and Haixia Feng, Correlation Analysis Between PM, Concentration and Meteorological, Vegetation and Topographical Factors in the Urbanized Ecosystem in Beijing, China Reena Ahuja and Naval Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater K. Arumugam, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling Using Visual Modflow in Tirupur Region, Tamilnadu, India Q. G. Li and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region of the Yellow River, China Binglin Huang, Mengxue Wang, Xinjun Jin, Yuxian Zhang and Guohua Hu, Effects of Different Tillage Measures on Soil Microbes and Enzymatic Activity Shihu Lin, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Study on the Efficiency of the Synchronous Alkali-ultranoic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digestion System Nur Aln Mohd Nizam Prusbotman, Megat Ahmad Kamal Megat Hanafiah, Noorul Faraham MA Arfff and Shariff Ibrahim, Ethylenediamineteraacetic Dianhydride (EDTAD) Modified Coconut Frond for Removal of PfOIII lons: Kinetics, Isotherm and Thermodynamic Wei He, Zheng Li and Dinggian Jing, Evaluation of Health Level of Land-use Ecosystem Based on GIS Grid Model Joo Olowoyo, L. Mpagane and S. Nyathi, Nature of Waste and Disposal Practices Among Different Business Holders Around Industrial Area of Kosslyn, Pretoria, South Africa Wei Her, G. Nasif, Basin, L. Wahab, Monimi, H. J. Hobori and		State, India: A Geoinformatic Approach	1367-1378
 L. P. Liang, O. Wang, F. F. Xi, W. S. Tan, Y. T. Zhang, L. B. Cheng, Q. Wu, Y. Y. Xue and X. Meng, Effective Removal of Cr(VI) from Aqueous Solution Using Modified Orange Peel Powder: Equilibrium and Kinetic Study 1391-1398 Haiying Feng and Haixia Feng, Correlation Analysis Between PM_{1,2} Concentration and Meteorological, Vegetation and Topographical Factors in the Urbanized Ecosystem in Beijing, China Reena AULj and Naval Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater K. Arrumgann, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling Using Visual Modflow in Tirupur Region, Tamilinadu, India Q. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desentification in the Source Region of the Yellow River, China Meighin Huang, Mengxue Wang, Xinjun Jin, Yuxian Zhang and Guohua Hu, Effects of Different Tillage Measures on Soil Microbes and Enzymatic Activity Shihu Liu, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Study on the Efficiency of the Synchronous Alkali-ultrasonic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digestion System Nur Ain Mohd Nizam Prushotman, Megat Ahmad Kamal Megat Hanafiah, Noorul Farhana Md Ariff and Shariff Drahim, Ethylenediamineetraacetic Dianhydride (EDTAD) Modified Coconut Frond for Removal of Pb(I) Ions: Kinetics, Isotherm and Thermodynamic J.JO. Olowoyo, L. Magane and S. Nyathi, Nature of Waste and Disposal Practices Among Different Business Holders Around Industrial Area of Rosslyn, Pretoria, South Africa Weit Re, Zhang A. Navalak, Monaim, H. Al-Jiboori and Abdurahhman, B. Ali, Temporal and Spatial Analysis of Alpha and Beta Activity Concentration at Al-Tuwaitha Site, Baghdad Suo. Glowoyo, L. Magane an	4.	Khan Ahmad Ali, Guoting Li and Wenchuan Wang, Comparative Study: The Adsorption Disparity for Tetracycline	
Effective Removal of CirVI) from Aqueous Solution Using Modified Orange Peel Powder Equilibrium and Kinetic Study 1391-1398 6. Haiying Feng and Haixia Feng, Correlation Analysis Between PM2_s Concentration and Meteorological, Vegetation and Topographical Factors in the Urbanized Ecosystem in Beijing, China 1399-1410 7. Reena Ahuja and Naval Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater 1411-1421 8. K. Arumugam, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling 1423-1433 9. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region of the Yellow River, China 1435-1442 10. Bingin Huang, Mengue Wang, Xinjun Jin, Yuxian Zhang and Guohua Hu, Effects of Different Tillage Measures on Soil Microbes and Enzymatic Activity 1433-1442 11. Nu Cai He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Study on the Efficiency of the Synchronous Alkali-ultrasonic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digestion System 1453-1463 12. Nur Ain Mohd Nizam Prushotman, Megat Ahmad Kamal Megat Hanaffah, Noorul Farhana Md Ariff and Shariff Ibrahim, Ethylenediaminetetraacetic Dianhydride (EDTAD) Modified Coconut Frond for Removal of Pb(II) Ions: Kinetics, Isotherm and Thermodynamic 1465-1142 13. Ku Atarta-F.Kunda (Babu), Causes of Air Pollution in Bangladesh's Capital Chy and Its Impacts on Public Health 1499-1505		and Cefradine on Cornstalk Biochar	1379-1390
 Haiying Feng and Haixia Feng, Correlation Analysis Between PM₂₅ Concentration and Meteorological, Vegetation and Topographical Factors in the Urbanized Ecosystem in Beijing, China Reena Ahuja and Naval Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater K. Arumgann, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling Visual Modflow in Tirupur Region, Tamilnadu, India Q. G. Lin and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region of the Yellow River, China Shilu Llu, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Study on the Efficiency of the Synchronous Alkali-ultrasonic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digeston System Nur Ain Mohd Nizam Prushotman, Megat Ahmad Kamal Megat Hamafiah, Noorul Farhana Md Ariff and Shariff Ibrahim, Ethylenediamineterbacetic Dianhydride (EDTAD) Modified Coconul Frond for Removal of Pb(II) Ions: Kinetics, Isotherm and Thermodynamic Wei He, Zheng Li and Dingqian Jing, Evaluation of Health Level of Land-use Ecosystem Based on GIS Grid Model Kudrat-E-Khuda (Babu), Causes of Air Pollution in Bangladesh's Capital City and Its Impacts on Public Health Jo. Olowoyo, L. Mpagane and S. Nyathi, Nature of Wate and Disposal Practices Among Different Business Holders Around Industral Area of Rossidh, Patroina, South Africa Werdyan, G. Nasasif, Basim, L Wahab, Monim, H. Al-Jiboori and Abdulrahhman, B. Ali, Temporal and Spatial Analysis of Alpha and Beta Activity Concentration at Al-Tuwaitha Sites. Baghdad Sancharf Biswas, Ch Ramakrishma and T A. Micha Prenkumar, Effect of Variable Compression Ratios on Performance and Emission Phenomena of DI CI Engine Fuelled with Pa	5.	L. P. Liang, Q. Wang, F. F. Xi, W. S. Tan, Y. T. Zhang, L. B. Cheng, Q. Wu, Y. Y. Xue and X. Meng,	
Topographical Factors in the Urbanized Ecosystem in Beijing, China 1399-1410 7. Reena Ahuja and Naval Kishore, Analysis of Watershed Characteristics of Nalagarh Watershed, Himachal Pradesh 1411-1421 8. K. Arumugan, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling 1423-1433 9. Q. G. Lin and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region of the Yellow River, China 1435-1442 10. Binglin Huang, Mengxue Wang, Xinjun Jin, Yuxian Zhang and Guohua Hu, Effects of Different Tillage Measures on Soil Microbes and Enzymatic Activity 1435-1442 11. Shihu Liu, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Study on the Efficiency of the Synchronous Alkal-iutansonic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digestion System 1453-1463 12. Nur Ain Mohd Nizam Prushotman, Megat Ahmad Kamal Megat Hanafiah, Noorul Farhana Md Ariff and Shariff Ibrahim, Ehylenediaminetteraacetic Dianhydride (EDTAD) Modified Coconut Frond for Removal of Pb(II) 1465-1474 13. Wei He, Zheng Li and Dingqian Jing, Evaluation of Health Level of Land-use Ecosystem Based on GIS Grid 1475-1482 14. Kudrat-E-Khuda (Babu), Causes of Air Pollution in Bangladesh's Capital City and Its Impacts on Public Health 148-1490 15. J.O. Olowoyo, L. Mpagane and S. Nyathi, Nature of Waste and Disposal Practices Among Different Business 1491-1497 16. Wedyan, G. Nassif, Basim, I. Wahab, Monim, H. Al-J		Effective Removal of Cr(VI) from Aqueous Solution Using Modified Orange Peel Powder: Equilibrium and Kinetic Study	1391-1398
7. Reena Ahuja and Naval Kishore, Analysis of Watershed, Characteristics of Nalagarh Watershed, Himachal Pradesh for Optimization of Recharge Structures and Management of Groundwater 1411-1421 8. K. Arumugam, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling 1411-1421 8. K. Arumugam, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling 1423-1433 9. Q. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region of the Yellow River, China 1435-1442 10. Binglin Huang, Mengxue Wang, Xinjun Jin, Yuxian Zhang and Guohua Hu, Effects of Different Tillage 1433-1442 Measures on Soil Microbes and Enzymatic Activity 1443-1452 11. Shihu Liu, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Sudy on the Efficiency of the Synchronous Alkali-ultrasonic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digestion System 1453-1463 12. Nur Ain Mohd Nizam Prushotman, Megat Ahmad Kamal Megat Hanafiab, Noorul Farhana Md Ariff and Shariff Ubrahim, Ehylenediaminetertaracetic Dianhydride (EDTAD) Modified Coconut Frond for Removal of Pb(II) Ions: Kinetics, Isotherm and Thermodynamic 1465-1474 13. Wei He, Zheng Li and Dingqian Jing, Evaluation of Health Level of Land-use Ecosystem Based on GIS Grid Model 1475-1482 14. K. Arurat-E-Khuda (Babu), Causes of Air Po	6.	Haiying Feng and Haixia Feng, Correlation Analysis Between PM25 Concentration and Meteorological, Vegetation and	
for Optimization of Recharge Structures and Management of Groundwater 1411-1421 8. K. Arumugam, T. Karthika, K. Elangovan, R.K. Sangeetha and S. Vikashini, Groundwater Modelling 1423-1433 9. Q. G. Liu and Y. F. Huang, Spatial and Temporal Changes and Driving Factors of Desertification in the Source Region of the Yellow River, China 1435-1442 10. Binglin Huang, Mengxue Wang, Xinjun Jin, Yuxian Zhang and Guohua Hu, Effects of Different Tillage Measures on Soil Microbes and Enzymatic Activity 1435-1442 11. Shihu Liu, Lei He, Pengcheng Zhao, Xuejie He, Xingxing Zhuo and Jian Zhou, Study on the Efficiency of the Synchronous Alkali-ultrasonic Pretreatment of the Low Organic Matter Sludge and its Influence on the Microbial Population in the Anaerobic Digestion System 1453-1463 12. Nur Ain Mohd Nizam Prushotman, Megat Ahmad Kamal Megat Hanafiah, Noorul Farhana Md Ariff and Shariff Ibrahim, Ethylenediaminetetraacetic Dianhydride (EDTAD) Modified Coconut Frond for Removal of Pb(II) Ions: Kinetics, Isotherm and Thermodynamic 1465-1474 13. We He, Zheng Li and Dinggian Jing, Evaluation of Health Level of Land-use Ecosystem Based on GIS Grid Model 1475-1482 14. Kudrat-E-Khuda (Babu), Causes of Air Pollution in Bangladesh's Capital City and Its Impacts on Public Health 1483-1490 13. J.O. Olowoyo, L. Mpagane and S. Nyathi, Nature of Waste and Disposal Practices Among Different Business 1491-1497 16. Wedyan, G. Nassif, Basim, I. Wahab, Monim, H. Al-Jiboori and Abdulrahhman, B. Ali, Temporal and Spatial Analysis of Alpha and Beta Activity Concentration at Al-Tuwaith		Topographical Factors in the Urbanized Ecosystem in Beijing, China	1399-1410
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 J.O. Olowoyo, L. Mpagane and S. Nyathi, Nature of Waste and Disposal Practices Among Different Business Holders Around Industrial Area of Rosslyn, Pretoria, South Africa Wedyan, G. Nassif, Basim, I. Wahab, Monim, H. Al-Jiboori and Abdulrahhman, B. Ali, Temporal and Spatial Analysis of Alpha and Beta Activity Concentration at Al-Tuwaitha Site, Baghdad Sanchari Biswas, Ch Ramakrishna and Y A Maruthi, Assessment of Heavy Metal Concentration in Tissues of Three Owl Species From Visakhapatnam, India V. Hariram, N. Balakarthikeyan, S. Seralathan and T. Micha Premkumar, Effect of Variable Compression Ratios on Performance and Emission Phenomena of DI CI Engine Fuelled with Palm Stearin Biodiesel-Diesel Blends Le Yang and Yue Zhang, An Evaluation of the Green Performance of Chinese New Energy Enterprises From the Perspective of Social Responsibility Wenfeng Gong, Tiedong Liu, Yan Jiang and Philip Stott, Applicability of the Surface Water Extraction Methods Based on China's GF-2 HD Satellite in Ussuri River, Tonghe County of Northeast China Xiongfei Cai, Xinjie Yu, Li Lei, Bin Xuan, Ji Wang, Lingyun Zhang and Shijie Zhao, Comparison of Lead Tolerance and Accumulation Characteristics of Fourteen Herbaceous Plants Wenju Zhao, Jiazhen Hu, Zongli Li and Jie Sheng, Variability and Modelling of Soil Moisture, Salt and Organic Matter Content in a Gravel-Sand Mulched Jujube Orchard Mahima Golani and Krishnan Hajela, Bioremediation of Diesel Oil Contaminated Soil by a Novel Isolated Potential Oil Degrading Staphylococcus argenteus MG2 Bacteria Using Bio Stimulation Method Bhawna Srivastava and P.B. Reddy, Haematological and Serum Biomarker Responses in Heteropneustes fossilis Exposed to Bisphenol A Hai-tao Chen, Ke-ke Xie and Wen-chuan Wang, Water Environment Quality Analysis Based on 	1.4		
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 Wedyan, G. Nassif, Basim, I. Wahab, Monim, H. Al-Jiboori and Abdulrahhman, B. Ali, Temporal and Spatial Analysis of Alpha and Beta Activity Concentration at Al-Tuwaitha Site, Baghdad Sanchari Biswas, Ch Ramakrishna and Y A Maruthi, Assessment of Heavy Metal Concentration in Tissues of Three Owl Species From Visakhapatnam, India V. Hariram, N. Balakarthikeyan, S. Seralathan and T. Micha Premkumar, Effect of Variable Compression Ratios on Performance and Emission Phenomena of DI CI Engine Fuelled with Palm Stearin Biodiesel-Diesel Blends Le Yang and Yue Zhang, An Evaluation of the Green Performance of Chinese New Energy Enterprises From the Perspective of Social Responsibility Wenfeng Gong, Tiedong Liu, Yan Jiang and Philip Stott, Applicability of the Surface Water Extraction Methods Based on China's GF-2 HD Satellite in Ussuri River, Tonghe County of Northeast China Xiongfei Cai, Xinjie Yu, Li Lei, Bin Xuan, Ji Wang, Lingyun Zhang and Shijie Zhao, Comparison of Lead Tolerance and Accumulation Characteristics of Fourteen Herbaceous Plants Wenju Zhao, Jiazhen Hu, Zongli Li and Jie Sheng, Variability and Modelling of Soil Moisture, Salt and Organic Matter Content in a Gravel-Sand Mulched Jujube Orchard Mahima Golani and Krishnan Hajela, Bioremediation of Diesel Oil Contaminated Soil by a Novel Isolated Potential Oil Degrading Staphylococcus argenteus MG2 Bacteria Using Bio Stimulation Method Bhawna Srivastava and P.B. Reddy, Haematological and Serum Biomarker Responses in Heteropneustes fossilis Exposed to Bisphenol A Hai-tao Chen, Ke-ke Xie and Wen-chuan Wang, Water Environment Quality Analysis Based on 	15.		1401 1407
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Tolerance and Accumulation Characteristics of Fourteen Herbaceous Plants1547-155522. Wenju Zhao, Jiazhen Hu, Zongli Li and Jie Sheng, Variability and Modelling of Soil Moisture, Salt and Organic Matter Content in a Gravel-Sand Mulched Jujube Orchard1557-156523. Mahima Golani and Krishnan Hajela, Bioremediation of Diesel Oil Contaminated Soil by a Novel Isolated Potential Oil Degrading Staphylococcus argenteus MG2 Bacteria Using Bio Stimulation Method1567-157624. Bhawna Srivastava and P.B. Reddy, Haematological and Serum Biomarker Responses in Heteropneustes fossilis Exposed to Bisphenol A1577-158425. Hai-tao Chen, Ke-ke Xie and Wen-chuan Wang, Water Environment Quality Analysis Based on1577-1584	21		1007 1010
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 24. Bhawna Srivastava and P.B. Reddy, Haematological and Serum Biomarker Responses in Heteropneustes fossilis Exposed to Bisphenol A 25. Hai-tao Chen, Ke-ke Xie and Wen-chuan Wang, Water Environment Quality Analysis Based on 	25.		1567-1576
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	25.		-0,, 1004
		Information Diffusion Theory and Fuzzy Neural Network	1585-1592

26.	Hongjun Xiong and Yi Shen, Influence of Government Subsidies for Green Technology Development on the Performance of Chinese New-Energy Automobile Enterprises	1593-1598
27	S. Nuanual, P. Maneechot, P. Thanarak, A. Phuruangrat and S. Artkla, Physicochemical Properties of	1375 1370
27.	Jatropha podagrica Biodiesel Blends and Their Effects on Tractor Engine Performance and Emission	1599-1605
28	Prabhat Kumar Rai and M. Muni Singh, Wetland Plants' Chemical Ecology for Iron of A Ramsar Site in An	1577 1005
20.	Indo-Burma Hotspot: In-Situ Bioaccumulation and Phytoremediation Implications	1607-1615
20	Y. Wang, Z. Wu, F.T. Li, Y. Deng, X.L. Liang and G. Wang, Comparison of Structural Stability and Erodibility	1007-1015
29.		1617 1626
20	of the Purple and Loess Soils Based on Le Bissonnais Method	1617-1626
50.	Manish Sharma and Pargin Bangotra, Lockdown Impact on Particulate Matter and Role of Meteorological	1(27.1(2)
21	Parameters in the Transmission of Covid-19	1627-1636
31.	T. B. Chudasama and S. J. Vyas, Socio-Economic Utility of Coastal Flora Growing in and Around Mangrol	1627 1644
22	Taluka (Junagadh) of Gujarat	1637-1644
32.	A.H. El Maghrabi, M.A. Marzouk, M.A. Elbably and M.E.M. Hassouna, Biosorption of Manganese by	
	Amended Aspergillus versicolor from Polluted Water Sources	1645-1656
33.	Keyuan Huang, Wangying Li, Yue Wang, Bin Liu, Ruolin Xu, Jing Dai, Xitong Zheng, Ningcan Yang,	
	Muqing Qiu and Li Han, Adsorption of Acid Orange 7 in Aqueous Solution by Biochar from Peanut Shell Supported	
	with Clay Mineral Kaolinite	1657-1662
34.	Wang Shouzhong, Zhou Zhen, Zhang Tong, Fang Xiaojun and Miao Chaoyang, Decontamination Efficiency	
	of Phenylethylene by an Activated Carbon-Based Adsorbent	1663-1668
35.	T. Kavimani, K. Balaji and G. Gnanapragasam, Combined Treatment of Real Sugar Industry and Sago	
	Wastewater Using Hybrid Upflow Anaerobic Sludge Blanket (HUASB) Reactor	1669-1674
36.	Prasenjit Mondal, B. P. Yadav and N. A. Siddiqui, Removal of Lead from Drinking Water by Bioadsorption	
	Technique: An Eco-friendly Approach	1675-1682
37.	K. Nagendra Naik, K. Yogendra and K. M. Mahadeva, Solar Light Induced Photodegradation of Brilliant Green	
	Dye by Barium Calciate (BaCaO ₂) Nanoparticles	1683-1688
38.	Zhaohua Leng, Operating Performance of China's Environmental Governance Industry Under the Impact of COVID-19	1689-1694
	Sattar Yunus, Makmur Saini, Rizal Sultan, Rusdi Nur and Ibrahim, The Effect of Ejectors on Reduction of	
	Indoor Air Pollution in the Welding Room	1695-1699
40.	Xin Huang and Lin Qiu, Study on Quantification Method for the Risk of Soil-Plant-Human System Environmental	
	Pollution Caused by Sewage Irrigation in Agriculture	1701-1705
41.	Xiuli Li and Xiaoyu Li, Evaluation of the Effect of Sewage Irrigation on Groundwater	1707-1712
	Jie Ma, Linhua Sun, Song Chen, Zhichun Li, Ting Gao, Hongbao Dai and Haitao Zhang, Hydrochemical	
	Characteristics and Water Quality Assessment of Surface Water and Groundwater in Agriculture Demonstration Base,	
	Jiagou District, Northern Anhui Province, China	1713-1721
43	H. Fitrihidajati, F. Rachmadiarti, F. Khaleyla and E. Kustiyaningsih, Effectiveness of Sagittaria lancifolia	1,15 1,21
	as Detergent Phytoremediator	1723-1727
44	Sheetal Barapatre, Mansi Rastogi, Savita and Meenakshi Nandal, Isolation of Fungi and Optimization of pH	1725 1727
	and Temperature for Cellulase Production	1729-1735
45	•	1729 1755
45.	P. Balaganesh, M. Vasudevan, S. M. Suneethkumar, S. Shahir and N. Natarajan, Evaluation of	
	Sugarcane and Soil Quality Amended by Sewage Sludge Derived Compost and Chemical Fertilizer	1737-1741
46.	Jianwei Lu, Industrial Pollution Governance Efficiency and Big Data Environmental Controlling Measures: A Case	
	Study on Jiangsu Province, China	1743-1748
	Jun Zhang, Hang Xu and Yang Li, Desulfurization of Fuel by [Bmim]CoCl ₃ and Potassium Monopersulfate	1749-1753
48.	B. Sajeena Beevi, G. Madhu and Praseetha P. Nair, Performance of Semi-dry Anaerobic Digestion of Organic	
	Solid Waste in Mesophilic Continuous Operation	1755-1762
49.	Shuchita Verma and Baljeet Singh Saharan, 16S rRNA Phylogenetic Analysis of Heavy Metal Tolerant Plant	
	Growth Promoting Rhizobacteria	1763-1766
50.	Najmus Sakib Khan, Md. Saiful Islam, Jaber Bin Abdul Bari and Naznin Akter Tisha, Water Quality	
	Evaluation by Monitoring Zooplankton Distribution in Wild Ponds, Noakhali, Bangladesh	1767-1770
51.	T.A. Adagunodo and O.P. Oladejo, Geoelectrical Variations in Residential Area of Ojongbodu, Oyo, Southwestern	
	Nigeria	1771-1774



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2020

The Effect of Ejectors on Reduction of Indoor Air Pollution in the Welding Room

Sattar Yunus*†, Makmur Saini**, Rizal Sultan***, Rusdi Nur**** and Ibrahim*****

*Department of Mechanical Engineering, Universitas Muslim Indonesia, Makassar, 90231, Indonesia **Department of Energy Conversion, Ujung Pandang State Polytechnic, Makassar, 90245, Indonesia ***Department of Electrical, Ujung Pandang State Polytechnic, Makassar, 90245, Indonesia ****Department of Mechanical Engineering, Ujung Pandang State Polytechnic, Makassar, 90245, Indonesia *****Department of Mechanical Engineering, Polytechnic of Industry, Makassar, 90213, Indonesia

[†]Corresponding author: Sattar Yunus; sattar.teknik@umi.ac.id

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INTRODUCTION

ABSTRACT

In this study, the ejector installation has been designed and processed according to the plan and further investigated the effect of the ejector's performance on reducing air pollutants in a welding chamber. This is done after gas and dust particles appear during the welding process. The measurement of air pollutants was carried out in two conditions. The first condition during the welding process was without using the ejector and the second condition is when the welding process continues and the ejector runs simultaneously. The measurements were made for carbon monoxide (CO) gas, nitrogen monoxide (NO) gas and total suspended particles. The ambient gas sampler was used in measuring CO and NO gases, while the Staflex air sampler measures dust particles. The results show that when the ejector is run or in the second condition, carbon monoxide and nitrogen monoxide and total dust particles are lower in concentration compared to the situation when the ejector is not running.

Vol. 19

The rapid industrialization over the past two decades has caused many problems in the environment, including air pollution whose influence has started to be felt and even become a pivotal problem today and certainly requires special attention in the development of a country (Lima et al. 2009), including in the City of Makassar, South Sulawesi Province. It is one of the cities in Indonesia which has air pollution trends increasing from year to year (Sattar et al. 2012, Sattar et al. 2019). The increasing number of the population is not only happening in developed countries but also in developing countries that have caused widespread air pollution (WHO 2005). Urban air pollution affects the health, well-being and lives of hundreds of millions of people, women and children every day in Asia. It was reported that outdoor air pollution causes around 537,000 deaths annually, indoor air pollution causes more than double the number of deaths (WHO 2002); this means that indoor pollution causes a greater impact than outdoor pollution especially in indoor activities that directly produce gases and particles (dust) which are quite dangerous for those exposed.

Based on the discoveries of historical objects, it can be seen that the technique of connecting metal known today with welding has been known since prehistoric times, for example, the contrasting of copper-gold alloy metal and lead-tin disordering. According to the information, it has been known and practised in the span of 4000 to 3000 years BC and alleged sources of heat come from burning wood and charcoal. In the 19th century, welding technology developed rapidly due to the use of electrical energy (Suharno 2008). According to Deutsche Industrie Normen (DIN), welding is a metallurgical bond on alloy metal joints that is carried out in hot and liquid conditions, further explained that welding is a process where the same material and type are combined together so that a connection is formed through the chemical bonds produced from the use of heat and pressure (Suharno 2008). Since there is a heat source, it will produce gases and particles where the gases that arise are dust (particles) in large welding fumes ranging from 0.2 µm to 3 µm. The chemical composition of welding smoke dust depends on the type of welding and electrodes used. When the hydrogen type electrode is low, there will be fluorine (F) and potassium oxide (K_2O) in smoke dust. In electric arc welding without gas, the smoke will contain a lot of magnesium oxide (MgO). The gases that occur during welding are carbon monoxide (CO), carbon dioxide (CO_2) , ozone (CO_3) and nitrogen monoxide gas (Wiryosumarto & Okumura 2004). In line with that when the welding process takes place, there are dangerous gases which need to be considered such as carbon monoxide gas

(CO). This gas has a high affinity for haemoglobin (Hb) which will reduce the absorption of oxygen, and the condition of the total suspended particles (TSP) also needs attention in the welding room (Harsono 1996).

In the effort to minimize the gases and harmful particles that arise in the room when welding takes place, a system or tool is required that can reduce gases or particles that occur. One method that can be done is by using the ejector method. The projector has succeeded used for polluted gas cleaning applications over the past few decades because of their ability to handle gases containing pollutants such as vapour, gas and solid/liquid aerosols up to 0.1 µm (Dutton et al. 1982, Subramarian et al. 2006). In line with this, it was stated that the ejector is one of the most important devices used in the industry. This device has two main tasks. One is to make a vacuum and remove gas and the other is to mix it in liquid. One of the tasks above or both can be considered in designing and using an ejector (Stefan & Hamjak 2008, Gamisansa 2002). In general, the main function of the ejector is to achieve maximum secondary flow in each of the main operating conditions given and to compress entangled masses in the ejector to the necessary release conditions (Chou 1996).

Based on this description, we will investigate in this study whether there is a reduction in the concentration of gases and particles in the air that arise specifically carbon monoxide (CO), nitrogen monoxide (NO) and total suspended particles (TSP) with tools that have been designed with the ejector method.

MATERIALS AND METHODS

Ejector Installation

The design of the ejector installation consisting of several core components such as cylindrical joints, reservoirs and

other components has been done and completed the installation as shown in Fig. 1.

Tools and Procedure Sampling

The implementation of the study is to examine the extent of the influence of the ejector tool that has been designed and made but will require direct testing to the actual environment, namely the industrial environment. As a testing phase, this tool is carried out in the student's welding practice room at the Makassar Industrial Engineering Polytechnic (ATI) Makassar, with the consideration that in the welding room when welding takes place there will be a range of air conditions with bad air condition, which certainly has an impact on welders or students who temporarily practice welding.

The entire air sampling process uses tools from the Environmental Engineering Centre and Makassar Class I Disease Control whose equipment is available and sufficient for sampling and also for the analysis of air samples that have been taken. The tool used for sampling air for gas is Ambient Gas Sampler (Impinger Model: MD-51MP), while TSP samples are used by the Staflex Air Sampler tool. Sampling was carried out in two air test conditions, namely:

- 1. Condition I (Ejector OFF): Retrieval and analysis of air samples when welding practices are taking place but the ejector has not operated. The data generated are as a control to see how much influence the ejector has.
- 2. Condition II (Ejector ON): Retrieval and analysis of air samples while ongoing welding practices and temporarily operated ejectors. Data generated will be compared with the data generated in the condition I.

Sampling Implementation Procedures

Supply installation equipment systems with electric power, throat length used was 30 cm (Saini et al. 2018). The pump

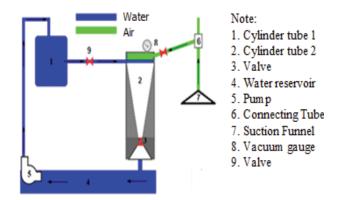


Fig. 1: Ejector installation design results.

engine (5) was operated to fill the reservoir (4). The valve (9) and valve (10) were opened and the valve (3) was closed until the cylinder (2) can be fully charged. The valve 9 and valve 10 were closed after the cylinder 2 was filled. The initial height of the reservoir water level (4) was measured and the ejector was run by the opening valve (3) and valve (10) so that the water is circulated continuously. The vacuum value was measured in the vacuum gauge (8) after opening the valve (10). Notes were taken and the level of water in the reservoir (4) was maintained. The throat ejector (3), which is 30 cm long, was set and used based on the results of previous tests. The ambient gas sampler tools and Staflex air samplers were operated and the time to start operating the tool in this step was recorded. Sampling tools were operated for 60 minutes, with three sampling times at 9-10, 10-11, 13-14 (in the case of students while doing welding, such as conditions when taking samples without running an ejector). After enough time, the ejector and the sampler were stopped. Air samples were taken to the BTKL-PP Laboratory for analysis.

RESULTS AND DISCUSSION

The air measurements in the welding room for carbon mon-

oxide are shown in Fig. 2. With the ejector condition not yet executed (OFF) the sampling at 9-10 a.m. showed CO concentrations of 2,384 ppm, at 11-12 a.m. of 2.43 ppm, and at 1-2 p.m. of 2,425 ppm. When the ejector is ON, at 09-10 a.m. CO concentration was 2,378 ppm, at 11-12 was 2.41 ppm, and at 1-2 p.m. was 2.39 ppm. Concentration when the ejector is carried out at all hours, the nine samples show a decrease in concentration, which more noticeably decreased at 1-2 p.m. This means that the longer the ejector is executed, the more carbon monoxide in the indoor air will be.

Based on the results of the air test for the nitrogen monoxide is shown in Fig. 3. With OFF ejector conditions at sampling at 9-10 a.m., NO concentration was 0.003 ppm, at 11-12 a.m. it was 0.004 ppm, while at 1-2 p.m. the concentration was 0.0045 ppm. Meanwhile, on the ejector ON condition at 9-10 a.m., NO concentration was 0.0025 ppm, at 11-12 a.m. it was 0.0039 ppm, while at 1-2 p.m. it was 0.0044 ppm. There appears to be a decrease in NO concentration when the ejector is run, but it is different from carbon monoxide which decreases a bit.

Based on the air measurement results in the welding room for the total suspended particles as shown in Fig. 4,

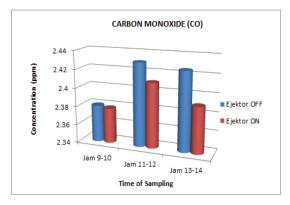


Fig. 2: Graph of CO concentration in the air when the ejector is OFF and ON.

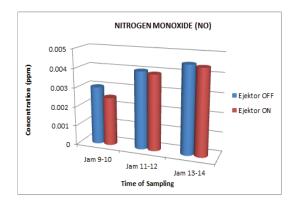


Fig. 3: Graph of the NO concentration in the air when the ejector is OFF and ON

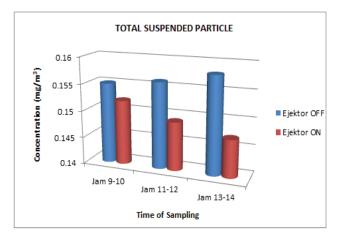


Fig. 4: Graph of TSP concentration in the air when the ejector is OFF and ON.

with the ejector not running, at 9-10 a.m. TSP concentration of 0.155 mg/m³ was obtained, 11-12 a.m. it was 0.156 mg/ m³, while at 1-2 p.m. the concentration was 0.158mg/m³. While the results of TSP measurements on the condition of the ejector ON at 9-10 a.m., the TSP concentration was 0.152mg/m³, at 11-12 a.m. it was 0.149mg/m³, while at 1-2 p.m. the concentration was 0.147 mg/m³. There appears to be a decrease in TSP concentration when the ejector was run, also like carbon monoxide, a reduction was seen at 1-2 p.m. sampling.

Based on the graphs of the data shown in Fig. 2 and Fig. 4, it seems that there are differences that can be observed, namely in the carbon monoxide, where the highest concentration in the sampling hours is at 11-12 a.m. both when the ejector is not executed and when the ejector is executed. Whereas in TSP measurements it appears that when the ejector has not been executed, the trend of TSP concentration appears to increase, and when the ejector is carried out, the total dust concentration (TSP) trend is decreasing. From both CO and TSP measurements, it appears that the total dust concentration decreases more (suspended particles) due to the effect of the ejector (4.47 %), compared to carbon monoxide (CO) (0.78%). One reason is that the particles have heavier mass than CO. In addition to larger sizes, the particles themselves can be categorized by diameter. If the diameter is smaller or equal to 2.5 microns, it is categorized as fine particles, if the diameter is between 2.5-10 microns it is categorized as coarse particles, whereas when the diameter is greater than 10 microns it is called total dust or total suspended particles (Sattar et al. 2014). The finer the particles have a higher impact on respiratory health (Rashid et al. 2014).

CONCLUSIONS

In this study, the reduction and recovery of pollutant gases and total dust have been carried out by sucking from the air by vacuum into a tube. Then the pollutant gases and particles are being sent into water that continues to circulate. The conclusions in this study are: There is a reduction in the concentration of carbon monoxide gas and total suspended particles by the operation of the ejector. The longer the ejector is operated, more the carbon monoxide and total suspended particles will be reduced. Compared to carbon monoxide gas, the concentration of total suspended particles appears to have a greater degree of reduction in all hours of sampling. The greater the vacuum, the higher will be the ability to reduce the concentration of carbon monoxide gas and total suspended particles.

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