

**A COMPARATIVE STUDY BETWEEN DUAL-MEDIA  
BOFS-SAND AND ANTHRACITE-SAND FILTERS  
IN TREATING RAW WATER**

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**ADLIL RAJIAH BINTI MOHD NASIR**

**Thesis Submitted in Fulfillment of the Requirement for the  
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**October 2010**

**Chairperson : Professor. Ir. Ahmad bin Jusoh, Ph.D.**

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Water pollution is reaching alarming levels particularly in industrial areas. Hence, there is a need to find practical alternative ways to solve the problem. Currently, mono-media sand and dual-media anthracite-sand filtration is popular in surface water treatment. However, in water treatment plant, mono-media sand filter can treat settled water only for about 24 hours or one day whereas anthracite media is quite expensive because it is imported from other countries. In addition, burned oil palm shell (BOPS) is abundantly available as solid wastes in our local industry. In this study, three types of filter media namely, sand, BOPS and anthracite with respective effective sizes of 0.5mm, 1.0mm and 1.0mm to treat raw water with initial concentration ranged from 70-80mg/L. Two types of filters constructed were mono-media sand, BOPS and anthracite filters as well as dual-media BOPS-sand and anthracite-sand filters. Each of these filters was triplicated prior to filtration process. This study was focused on several parameters such as effective size and porosity of the filter media, effluent quality in terms of turbidity and total suspended solids (TSS), specific sediment deposit development, head loss progress and total operation time taken by a particular filter. Evaluation of the performance of BOPS as a potential filter media in a dual-media BOPS-sand filter and compared to the dual-media anthracite-sand filter, the result was determined in two ways which is by simulation and experimental procedure. Simulation made was using Tufenkji and Elimelech's (TE) model and also Rajagopalan and Tien's (RT) model where both models were incorporated with matrix approach. The filtration unit was constructed with 5 cm width and 250 cm height as well as specified flow rate of 5.81m/hr. Simulated outcomes was then compared with the experimental data and the closeness was studied. The filtration efficiency and percentage of suspended solids removal was found to be inversely proportional to the effective size of filter media and hence sand media was considered to have the highest efficiency. From the experiment, the average of suspended solids removal percentage of mono-media filters was determined which were 86.3% for sand media, 85.1% for BOPS media, and 85.3% for anthracite media. Meanwhile, the removal percentages for dual-media

filters were 91.4% for BOPS-sand media and 91.6% for anthracite-sand media. All effluent turbidity produced by every mono and dual-media filter achieved less than 1 NTU as stated in water quality standard. In terms of total operation time, dual-media filters were revealed to be able to lengthen the operation time up to 14 times longer (from 5hr to 68hr) since they enhance the filter capacity using BOPS and anthracite media. Hence, the maintenance of these filters becomes more convenient and cheap since they require less backwashing process. This method and analysis in this study was found to be accurate as the simulated results fitted very well with the experimental data. Dual-media BOPS-sand filter was verified to have a high performance in producing a compatible effluent turbidity as compared to conventional mono-media sand filter and also found to have a comparable performance with the commercial dual-media anthracite-sand filter. Dual-media BOPS-sand filter could be a more economical yet effective solution in treating raw water.



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## **KAJIAN PERBANDINGAN ANTARA PENURAS DWI-MEDIA BOPS-PASIR DAN ANTRASIT-PASIR DALAM MERAWAT AIR MENTAH**

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Masalah pencemaran air semakin meruncing terutamanya di kawasan perindustrian. Oleh itu, suatu cara alternatif yang praktikal perlu dicari untuk mengatasi masalah ini. Ketika ini, penurasan laju adalah sangat terkenal dalam rawatan air permukaan untuk pembekalan air. Walaubagaimanapun, dalam loji rawatan air, penuras mono-media pasir boleh merawat air terenap dalam masa 24 jam atau sehari sahaja manakala media antrasit hanya boleh didapati dengan harga yang tinggi kerana ianya diimport dari negara luar. Tambahan pula, tempurung kelapa sawit bakar (BOPS) banyak didapati dalam bentuk bahan buangan pepejal di dalam industri-industri tempatan. Dalam kajian ini, tiga jenis media penuras digunakan iaitu pasir, BOPS dan antrasit dengan saiz berkesan masing-masing adalah 0.5mm, 1.0mm dan 1.0mm untuk merawat air mentah dengan kepekatan awal berjulat antara 70-80mg/L. Dua jenis penuras yang telah dibuat adalah penuras mono-media pasir, BOPS dan antrasit serta dual-media BOPS-pasir dan antrasit-pasir. Kajian ini tertumpu kepada beberapa parameter iaitu saiz berkesan dan keliangan media penuras, kualiti efluen dari sudut kekeruhan dan jumlah pepejal terampai (TSS), perkembangan deposit endapan, kehilangan turus serta jumlah masa penurasan. Bagi menilai kecekapan BOPS sebagai media penuras yang berpotensi dalam penuras dual-media BOPS-pasir dan dibandingkan dengan penuras dwi-media antrasit-pasir, keputusan ditentukan melalui dua cara iaitu simulasi dan eksperimen. Simulasi yang dibuat adalah menggunakan model Tufenkji dan Elimelech (TE) serta Rajagopalan dan Tien (RT) di mana kedua-dua model ini disatukan dengan kaedah matriks. Unit penuras ini dibina dengan lebar 5cm, tinggi 250cm serta pada kadar alir air tertentu iaitu 5.81m<sup>3</sup>/j. Simulasi yang dibuat kemudiannya dibandingkan dengan data eksperimen dan ketepatan data-data itu dikaji. Kecekapan penurasan dan peratus penyingkiran pepejal terampai didapati berkadar songsang dengan saiz berkesan media penuras dan dengan itu, pasir dikatakan mempunyai kecekapan yang terbaik. Dari eksperimen, purata peratus penyingkiran pepejal terampai untuk penuras mono-media

pasir, BOPS dan antrasit masing-masing adalah 86.3%, 85.1% dan 85.3%. Sementara itu, peratusan untuk penuras dual-media BOPS-pasir dan antrasit-pasir masing-masing adalah 91.4% dan 91.6%. Semua kekeruhan efluen yang dihasilkan oleh setiap penuras mono dan dwi-media mencapai kurang daripada 1 NTU sepertimana yang ditetapkan oleh piawaian kualiti air. Dari sudut masa penurasan, penuras dwi-media telah berjaya memanjangkan masa penurasan kerana BOPS dan antrasit yang digunakan telah meningkatkan kapasiti penuras. Oleh yang demikian, penyelenggaraan penuras ini menjadi lebih mudah dan murah kerana memerlukan kurang proses basuhan balik. Kaedah dan analisa di dalam kajian ini didapati tepat kerana simulasi hampir menyamai data eksperimen. Penuras dual-media BOPS-pasir telah disahkan mempunyai kecekapan yang lebih baik daripada penuras mono-media pasir serta setanding dengan kecekapan penuras komersil dual-media antrasit-pasir. Penuras ini juga merupakan penyelesaian efektif dan menjimatkan dalam merawat air mentah.