中華醫事科技大學
教師研究獎助計畫成果報告

評估粒狀活性碳去除不同液體清潔劑有機體營養物之關係
An assessment of granular activated carbon for detergent with respect to organics and nutrients

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計畫主持人：陳達立

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一、中文摘要

清潔劑對環境污染:台灣各都市未建立完善之下水道系統，近年來廚房清潔劑、洗碗精：前者磷酸鹽和氯化漂白劑，會惡化水質，後者的色素會污染河川。家庭污水的特性：依據調查統計，家庭污水的水量及水質具有下述特性：

1.各家庭所排洩出來的污水量以每人每日計，約為二百到二百五十公升左右。相對的，屎尿廢水的部份為每人每天五十公升左右。

2.一般家庭的生活污水，依其用途別換算所得的百分比，各為廚餘 20% ，洗衣 30% ，洗臉、刷牙、洗手等 10% ，洗澡 20% ，廁所沖洗用水 13% ，其他占 7% 。

3..家庭污水的污染量以每人每天計，生化需氧量三十至四十公克、氮一至三公克，磷零點三至零點九公克。至於家庭污水外的屎尿廢水，其生物需氧量則有十三至十八公克。

4.廚餘廢水中含有有機性污染物質，占全部家庭污水有機污染物含量的大部份。洗衣時使用含磷洗濯劑時，其含磷量將占全部家庭污水含磷量的 50% 。

家庭污水對河川的污染以淡水河為例：淡水河系流經大台北都會人口密集地區，流域集居人口達五百四十萬人，由於缺乏污水下水道及處理設施，家庭及都市污染絕大部份均未經妥善處理，直接排入河川，為本流域河川污染的主要來源，占各污染源的 65% 。按每人每日水量二百公升估計，排污區總污水量估計約一百零八萬噸，同時考慮排入之岸邊垃圾滲漏之污水量，則家庭產生的污染量估計每日約二百一十七噸。淡水河家庭污水生化需氧量 BOD 污染量占 64.8% 。

家庭雜排水中，烹調廢油一向是最大污染源之一，而為了去除廚房油污，主婦買各種去污洗劑刷洗，又造成水源二度污染。液體清潔劑對肌膚或毛髮很不好，除了有化學合成的界面活性劑外，會添加一些些營養成分，但是營養成分需要再添加防腐劑及抗氧化劑才能長時間保存，而液體環境下需要有抗菌劑，否則容易發霉生菌。洗劑的成分可區分為主劑與助劑兩大項。主劑即為界面活性劑，作用在去污，至於界面活性

劑以外的成分，則全是助劑就是在提升洗劑的清潔力，並防止洗滌物逆吸收污水、漂白，預防洗劑粉末潮濕結塊等。市面上清潔劑超過 3 成以上含有環境賀爾蒙，不過環境賀爾蒙的污染卻洗越多，根據學者調查，這些清潔劑中含的環境賀爾蒙就是壬基酚，醫學證實會更造成男性雌性化，生殖細下降，會引發女性乳癌。

對環境的影響(間接傷害)：生物分解度低的界面活性劑，其殘留於大自然環境中的化學物質產生的環境污染、河川的優氧化、河水變臭、酸雨...等等，生活週遭有那麼多的化學物質存在(化妝品、清潔劑、洗碗精、洗衣精、漂白劑、柔軟精、沐浴乳)，如何減少化學產品與提高自身免疫力實為現代人所需具備的觀念。

1.洗衣用合成洗劑:現在的洗衣用合成洗劑，大約含有 41%的合成界面活性劑，亦即雖然具有強大的去污力，但是毒性也大幅提升了。

2.廚房用合成洗劑:市售的廚房用合成洗劑，約含有 26～27%的合成界面活性劑。廚房用合成洗劑可能會殘留在餐具上，如果不稀釋原液就直接使用，反而比洗衣用合成洗劑的問題更加嚴重。

3.洗髮精:合成界面活性劑含量為 16～27%,會破壞頭髮根部的細胞造成掉髮或頭皮屑增加，同時也是生成白髮的最大原因。

4.沐浴精:近年來，沐浴精深受大家歡迎，這就好像將合成界面活性劑塗抹在全身一樣，絕對要停止這種危險的行為。

5.潤絲精:潤絲精的成分除了合成界面活性劑之外，還包括合成香料，抗靜電劑、殺菌劑等。

6.營養鹽: 若使用清潔劑，往往含有氯及磷酸鹽等物質，使水質惡化。人類活動釋放的營養鹽也可能造成水污染。兩種可能造成污染的元素是：磷和氮，來源是肥料、清潔劑及汙水處理廠的產物。城市地區還會增加額外的磷和氮，尤其是在廢水處理廠將處理過的水排入河流、湖泊或海洋。這些處理廠再降低有機污染物和致病生物很有成效，但是沒有進一步處理水中的營養鹽。

7.粒狀活性碳原理:吸附主要乃將廢氣中之物質，通過一多孔固體，使之附著於其固體表面上，來達到去除之目的。吸附的機制一般依鍵結作用方式可分為物理吸附及化學吸附兩種。

活性碳吸附會隨廢水 pH 值降低而增加，pH 值大於 9 時，吸附效率極差，因此高 pH 值之廢水需加以調整，且維持穩定，pH 值之突然上升，可能會造成原來已吸附之有機物再脫落。處理高濁度與高有機物含量之廢水，可能會堵塞活性碳之孔隙，而損失吸附容量，活性碳之吸附量及其使用壽命可因良好之前處理操作而得以發揮，同時可以獲得最好之處理水質。

化學需氧量:化學藥品也能使水中的有機物所需的化學劑量換算成相當氧量，就稱為化學需氧量(COD)。以表示水中樣可被氧化有機物之含量。
水中污染物越多，生物需氧量和化學需氧量也會提高，一個良好的水域須具有高的溶氧量及低的生物需氧量與化學需氧量。

當水中的污染物超過了一定的限度，河川中的溶氧量就會大量降低，而生物需氧量和化學需氧量也相對的提高，水中微生物的種類及作用型態也跟著改變，轉為產生甲烷、硫化物、氨等惡臭物質，這時就成了所謂死的河川。這種死的河川，水色黑濁，時而散發臭氣，不適於魚貝生長，更影響都市觀瞻及環境衛生，甚至威脅到自來水的供應和農產品的安全性。

關鍵詞：粒狀活性碳; 化學需氧量; 營養鹽;界面活性劑

二、英文摘要

An assessment of granular activated carbon for detergent with respect to organics and nutrients

Abstract

A detergent is a formulation comprising essential constituents (surface active agents) and subsidiary constituents (builders, boosters, fillers and auxiliaries) The production of waste from human activities is unavoidable. It is possible to reduce the total waste discharge by applying cleaner technology in household.

The investigation was undertaken to compare the adsorption efficiency of granular activated carbon with respect to uptake of the organics components responsible for the chemical oxygen demand (COD) and nutrients(phosphate and nitrate) of detergent. The phosphate and nitrate content of detergent influences the phosphorous and nitric load significantly. Chemical Oxygen Demand (COD) reductions in the wastewater of up to 30~50% have been achieved resulting in less environmental impact and lower wastewater disposal costs.

Activated carbon is carbon treated at high temperature with a physical or chemical activating agent producing an internal porous particle structure and has been used for many years in wastewater treatment. Granular activated carbons can be used for adsorption of gases and vapors and those in purification of liquids for which a powdered material is desired. Granular activated carbons (GACs) are used within a column for water treatment. The water flows through the carbon bed, where organic molecules present as contaminants are adsorbed on to the carbon surface. When the carbon is saturated with the adsorbed molecules, the carbon loses its adsorptive ability, and is removed from the system and regenerated.

Surface Active Agent: Chemical compound which, when dissolved or dispersed in a liquid is preferentially absorbed at an interface, giving rise to a number of physico-chemical or chemical properties of practical interest. The molecule of the compound includes at least one group with an affinity for markedly polar surfaces, ensuring in most cases solubilization in water called amphiphilic products, and a group which has little affinity for water.

Environmental Issues

Propylene tetramer benzene sulphonate held almost undisputed sway as the major ingredient used in washing operations till the early 1960s. Around this time it was noted, however, that sewage treatment problems were arising. The amount of foam on rivers was increasing and where water was being drawn from wells located close to household discharge points, the water tended to foam when coming out of the tap. This was attributed to the fact that propylene-based alkyl benzene sulphonates are not completely degraded by the bacteria naturally present in effluents, and was further narrowed down to the fact that it is the branched-chain formation of the alkyl benzene which hinders the attack by the bacteria. However, fatty acid sulphates were found to degrade very easily, and since all naturally occurring fatty acids from which fatty alcohols are produced are of the straight-chain variety (as also are the Ziegier alcohols which started appearing in commercial quantities at about this time), it seemed possible that a straight-chain alkyl benzene might be degradable.

Methods of test were developed and it was, in fact, proved that linear alkyl benzene is biodegradable. Germany introduced legislation prohibiting the discharge of non-biologically degradable material into sewer systems. In the USA detergent manufacturers agreed voluntarily to switch over from PT benzene to linear alkyl benzene by June 1965. In the United Kingdom a similar type of 'gentleman's agreement' was entered into.

The change to linear alkyl benzene (which can be considered as a return to a purified form of the keryl benzene in use twenty years previously) gave some rather surprising results. It was found that the detergency in a heavy-duty formulation using linear alkyl benzene sulphonate was approximately 10 per cent better than when using PT benzene sulphonate, solutions of the neutralized sulphonic acid had a lower cloud point, and pastes and slurries had a lower viscosity. The first two results were obviously advantageous and a lower viscosity in slurries had an advantage when the product was spray-dried to a powder, but when the LAS was sold as a liquid or paste detergent, this lower viscosity had to be overcome as sales appeal was lost. The manufacture of powders based on LAS posed some problems, however. Powders became sticky and lost their free-flowing characteristics, whether made by spray-drying or one of the other methods.

Mausner and Rainer' have indicated that the actual isomer distribution of the linear alkylate has an effect on the stickiness of the powder, with the 2-phenyl isomer giving the greatest tendency to stickiness and the 5- or 6-phenyl isomer the least. Additives to overcome this tendency have therefore been developed.

The switch to linear alkyl benzene is not, however, complete. In many parts of the world where the problem of sewage treatment is not serious, the PT benzene is still being used in ever-growing quantities. Also the Ziegler alcohols are now competitively priced with the linear alkyl benzenes, and alkane sulphonates are reappearing. Having successfully coped with the problem of biodegradation the industry faced a new attack. It appeared that in certain lakes and ponds algae started reproducing at an unprecedented rate. This was blamed on the extensive use of phosphates which are a food for these organisms, and again the detergent industry became the whipping boy, because tremendous amounts of sodium tripolyphosphate are used and then discharged down the sewer. (The term eutrophication, meaning nutrition by chemical means, has been applied to this phenomenon.) It is not clear whether the blame should be taken solely by the detergent industry, as concurrently with the increase in the use of detergent phosphates there was an increase in the use of phosphate fertilizers, which also find their way into natural water systems. However, with the big international preoccupation with ecology the detergent industry is searching for an efficient substitute for sodium tripolyphosphate.

To date a complete replacement has not been found but in the Scandinavian countries particularly, formulations of household powders are beginning to appear with appreciable portions of the phosphate replaced by NTA (nitrilo triacetic acid) which is a better sequestering agent than tripolyphosphate but has none of the other properties exhibited by the phosphate. There are fears that in time the extended use of NTA might bring new problems of this sort, as it contains nitrogen which is again a good fertilizer and nutrient for algae.

The search is still going on for a phosphate substitute. NTA on its own will only partially replace phosphates. A mixture of NTA and borax has been suggested as a complete replacement but here again the borax might produce more problems than the phosphate is alleged to produce. Some of the hydroxy-polycarboxylic acids not containing nitrogen are also being considered.

Enzymes

The biggest single revolutionary trend in the detergent industry in the latter years has been the use of enzyme additives. Enzymes as aids to washing are not new to the industry. Proteolytic enzymes had been tried as additives to washing powders in Germany in the 1920s with only moderate success and again in Switzerland in the 1930s. Enzymes, which can be called organic catalysts, tend to hasten reactions and the proteolytic enzymes convert or 'break down' proteins wholly or partially into amino acids. The action is rather slow and the production costs high, but with improved methods of production and purification, strains of enzymes, usually in admixture with a proportion of amylase which breaks down starches, were developed which were relatively fast acting. These were added initially to 'pre-soak' detergents and found immediate acceptance in the European countries where washing habits were such that washing was normally soaked for a period prior to the wash proper.

Better and better strains of enzymes were developed, with stability to a wider pH spectrum, stability against perborate and quicker action. In the United States detergent manufacturers resisted the incorporation of enzymes into their powders for some years after this type of

powder had almost completely swept the board in Europe but in 1968 enzymatic powders started appearing there as well. The position at present is that enzymatic powders are now holding a large proportion of the household detergent market and formulations appeared made for machine washing. Some washing-machine manufacturers are now producing automatic washing machines with a 'Bio' programme which allows the washing to remain in contact with the detergent solution for an extended period of time at a relatively low temperature before beginning the washing and heating cycle. The future of enzymes is at the moment obscure as the production of enzymatic powders has raised its own problems, and one Scandinavian firm has already decided to withdraw its powder containing enzymes from the market, but other large firms are taking enzymes out of some of their powders while forging ahead with others

Keywords: liquid detergent; Granular activated carbons

三、緣由與目的

臺灣地區家庭廢水污染量以生化需氧量計約每人每日四十公克，總污染量為八五二噸/每日,經下水道化糞池及水肥處理廠處理後，其排放量為七四四噸/日，削減率僅為一二・七%佔臺灣地區水污染主要來源之四０・一%，已超越工業廢水而各大都會區周邊河川如淡水河、田寮河、中港溪及大甲溪等生活污水佔污染源之比例高達五十至九十%以上，生活污水已成為都市周邊河川最重要污染源，因此，要改善生活污水污染有賴民眾共同戮於家庭減廢工作。

清潔用品是每個家庭不可或缺的物品，它幫助清潔者輕鬆去除污垢，維持居家環境的清潔，因此家庭主婦常選用清潔力強的清潔用品，但往往標榜強力清楚效用的清潔品，卻會對環境造成極大傷害力。

家中使用的洗衣粉是不是具有環保概念的綠色洗衣粉？為減輕清潔劑對環境的影響，有些製造廠商改變洗衣粉成分，去除洗衣粉內所含的一種叫做磷酸鹽的化學物質。磷酸鹽能增進去污功效，增加泡沫，但是它們到了湖裡和河裡，就會導致藻類迅速繁殖，把水中所有的氧氣都吸收光，而使其他生物窒息。

化學需氧量(COD)： 化學需氧量代表水中可破強氧化劑氧化的有機物量。測定時取定量的廢水，以重鉻酸鉀在酸性下氧化有機物產生 CO2 及 H2O，再計算氧化消耗的氧量。 COD 的測定，廣泛用於工業廢水及家庭污水之有機物含量分析。

氨氮是生物活動及含氮有機物分解的產物，可指示污染。氮在污水中的主要狀態有

氨氮(NH3-N)，亞硝酸氮(NO2-N)，硝酸氮 (NO3-N)，有機氮等，其中氨氮及有機氮的和稱為總凱氏氮。通常可藉氮的測定，以控制生物處理淨化的程度。污水中的磷一般以正磷酸監及聚磷酸鹽存在。若水中濃度高，表示可能受工礦廢水、家庭污水、清潔劑、肥料等污染。湖泊、水庫的藻類滋生，亦受到磷的影響。

台灣地區公共污水下水道普及率僅 8.7 %（營建署，2002 年)。在污水下水道未普及地區，民生污水大致只經由單獨式化糞池(Septic tank ）簡易處理，其餘之廚房、浴室、洗衣、洗滌等生活雜排水，則大部分未經任何處理就逕行排放，致使河川污染問題日益嚴重，由環保署統計室統計結果顯示，截至民國九十年底為止，生活污水佔水體污染量的百分之五十二點九(環保署統計室，2002 年)。家庭雜排水又包括廚房用水、洗衣用水、沐浴用水和其他。平均每人每日用水量約為 250~300 公升，其中約有 80 % 以上會轉成廢(污)水，此家庭雜排水大部分未經處理即逕行排放，對環境水體造成了相當大的污染(黃政賢，1997 年)；(Rahman, Ausaf-ur., 1996)

四、結果與討論

由這個實驗結果發現，實驗樣品裏五種清潔劑有白蘭洗衣精、洗髮乳、嬌生洗手乳、妙管家洗衣精、毛寶冷洗精，其白蘭洗衣精酸鹼值 pH 值為 8.02、洗髮乳 pH 值為 7.84、嬌生洗手乳 PH 值為 7.83、妙管家洗衣精 pH 值為 7.93、毛寶冷洗精 pH 值為 7.84，其中嬌生洗手乳實驗測得 pH 值為 7.83 為偏鹼性而商品上面寫著 pH 值為 5.5 偏酸性是不正確的，清潔劑絕大部分都為鹼性。

樣品裏五種清潔劑振盪 30min 和振盪 12hr 未經過活性碳吸附直接測量化學需氧量 COD 值，白蘭洗衣精 COD 值最高為 809mg/l 中對環境危害最大，嬌生洗手乳 COD 值 338mg/l 危害最小，其次依序為洗髮乳、毛寶冷洗精、妙管家洗衣精，實驗樣品裏五種清潔劑使用不同重量粒狀活性碳振盪 30min，五種清潔劑 COD 去除率（%）中以白蘭洗衣精在粒狀活性碳 2.0g 為 29.4%最好，粒狀活性碳 1.0g 為 13.0%最差，洗髮乳在粒狀活性碳 3.0g 為 21.4%最好，粒狀活性碳 2.0g 為 16.5%最差，嬌生洗手乳在粒狀活性碳 1.0g 為 24.0%最好，粒狀活性碳 3.0g 為 1.8%最差，妙管家洗衣精在粒狀活性碳 2.0g 為 42.5%最好，粒狀活性碳 0.5g 為 15.7%最差，毛寶冷洗精在粒狀活性碳 3.0g 為 33.0%最好，在粒狀活性碳 0.5g 為 16.7%最差。

在COD去除率裏去除率數字愈大表示活性碳去除有機物效率愈好對環境影響有減輕之趨勢，而所加入活性碳愈多 COD 去除率愈未必相對提高，COD 去除率在同重量活性碳加入振盪 12hr 會比振盪 30min 為好，而在振盪 30min 時實驗樣品裏五種清潔劑以毛寶冷洗精最具規律性亦即加入活性碳愈多，而 COD 去除率愈好。實驗樣品裏五種清潔劑 pH 值由大至小分別為白蘭洗衣精 pH 值為 8.02 大於妙管家洗衣精 PH 值為 7.93 大於毛寶冷洗精和洗髮乳 pH 值為 7.84 大於嬌生洗手乳 pH 值為 7.83 綜合上述，在實驗樣品裏五種清潔劑中未以活性碳加入以COD值而論單位重量毛寶冷洗精為對環境影響最小，而單位重量白蘭洗衣精為最差，亦即對環境污染最嚴重對生態環境影響最大。

五、計畫成果自評

本計畫重點係以粒狀活性碳去除水中的營養鹽為對象，經由COD去除率裏去除率數字愈大表示活性碳去除有機物效率愈好對環境影響有減輕之趨勢應用落實。計畫目標係針對臺灣地區家庭廢水污染量以生化需氧量計約每人每日四十公克，了解五種清潔劑成份形成水體污染量之自然與人為因素，提醒大眾清潔用品雖是每個家庭不可或缺的物品，它幫助大眾輕鬆去除污垢，維持個人及居家環境的清潔，因此家庭主婦常選用清潔力強的清潔用品，但往往對標榜強力清楚效用的清潔品，卻不知會對環境造成極大傷害力。務應用面為出發點，將最創新之污染防治觀念導入，提供環保政策及法規之規劃及執行面相關資料。

六、參考文獻

1.Ahel, M. and Giger, W. 1993. Partitioning of alkylphenols and alkylphenol polyethoxylates between water and organic solvents. Chemosphere, 26: 1471-1478

2. Reinhard,M and Goodmann,N.1982.Occurrence of brominated alkylphenol polyethoxy carboxylates in mutagenic waste water concentrates Envirn. Sci . Technol. .,16:351-362.

3.Sharpe,T.M.,Fisher,J.S.Millar,M.M.,Jobling,S.and Sumpter,J.P.1995.Gestational and lactational exposure of rats to xenoestrogens results in reduced testicular size and sperm produ ction,

Environ. HealthRespect .,103:1136-1143 .

4. Maruan Ahel,Walter Giger and Christian Schaffner.1994.Behavior of alkylphenol polyethoxylate surfactants in the aquatic environment-II occurrence and transformation in rivers. Water res.,28:1143-1152 .

5. D.T. Bennie,C.A. Sullivan,H-B. Lee,T.E.
Peart,R.J.Magurie.1997.Occurrence of alky lphenol mono- and diethoxylates in natural waters of the Laurentian Great Lakes basin and the upper St. Lawrence River.The science of the total environment, 193:263-275 .

6. Soto,A.M.,Justicia,H. and Wray,J.W.1991.Para-Nonylphenol an estrogenic xenobiotic r elease from modified polystyrene,Environ.Health.,92,167-173

7.Giger,W.;Ahel,M;Koch,M.;Laubscher,H.U.;Schaffner,C.;Schneider,J.Water sci. Tech nol,1987,19,449 .

8. Jorn Thiele,Klaus Gunther,andMilan Johann Schwuger.1997.Alkylphenol ethoxyla tes:trace analysis and environmental behavior..Water Res. 97:3247-3272 .

9. Ding,Wang-Hsien,Tzing,Shin-Haw,Lo,Jun-Hui.1999. Occurrence and concentrations of aromatic surfactants and their degradation products in river waters of Taiwan.Chemosphere. 38:2597-2606

10. American Public Health Association, American Water WorksAssociation&Water Environment Federation. 1992.StandardMethods for the Examinationof Water and Wastewater,18thEd., pp. 5-6 ～ 5-8. APHA, Washington,D.C.,USA .

11. Wayne T. Davis, “Air Pollution Engineering Manual” , *Air & Waste Management Association*, 2nd ed., pp. 37-43, 2000.

12. Trybal R. E. “Mass Transfer operation” , *McGraw-Hill*, 3rd ed., pp.624, 1980.

13. 中央大學化學系副教授丁望賢

14. 環保署，事業廢水處理之改善評鑑與管理手冊 - 建築物污水處理設施，民國 82 年 2 月

15.環保署，生活雜排水對策推進指導方針，民國 81 年 1 月

16.環保署，生活雜排水對策推進指導方針，民國 81 年 1 月

17.台北市建築物污水處理設施及清理機構管制計畫，台北市環保局，民國 85 年 6 月

18. http://www.phoenix-biotech.com.tw/beautiful8all.htm
19. 柳文成，「濕地廢污水處理適用性及限制之探討」，國科會研究計劃 (NSC90-2211-E-002-082)
20. Meuleman, A. F. M., "Waterzuivering Door Meras-system：Onderzoek naar de Water-en Stofbalansen Van Het Rietinfiltratieveld Lauwersoog. RIZA Nota 94.011,pp. 1-134(1994)

振盪 30min 與 12hr 清潔劑與不同重量之活性碳的 COD 值與 COD 去除率（%）

清潔劑名稱	**白蘭洗衣精**,pH=8.02			
振盪時間	30min		12hr	
粒狀活性碳重量(g)	COD(mg/L)	COD 去除率（%）	COD(mg/L)	COD 去除率（%）
0.0	809		809	
0.5	649	19.8		
1.0	704	13.0	352	56.5
2.0	571	29.4	299	63.0
3.0	595	26.5	517	36.1

清潔劑名稱	**洗髮乳**,pH=7.84			
振盪時間	30min		12hr	
粒狀活性碳重量(g)	COD(mg/L)	COD 去除率（%）	COD(mg/L)	COD 去除率（%）
0.0	721		721	
0.5	587	18.6		
1.0	591	18.0	275	61.9
2.0	602	16.5	246	65.9
3.0	567	21.4	391	45.8

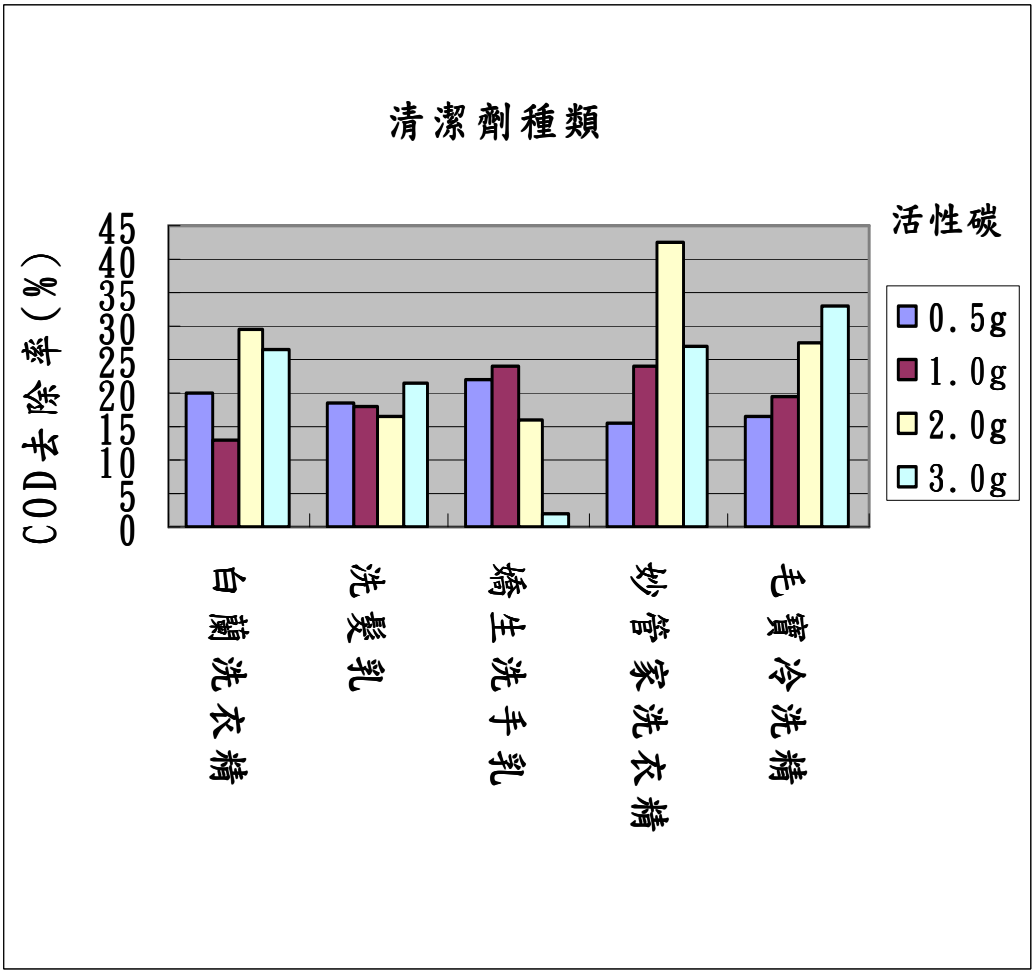
清潔劑名稱	**嬌生洗手乳**,pH=7.83			
振盪時間	30min		12hr	
粒狀活性碳重量(g)	COD(mg/L)	COD 去除率（%）	COD(mg/L)	COD 去除率（%）
0.0	338		338	
0.5	264	21.9		
1.0	257	24.0	88	74.0
2.0	284	16.0	393	(16.3)
3.0	332	1.8	933	(176.0)

清潔劑名稱	**妙管家洗衣精**,pH=7.93			
振盪時間	30min		12hr	
粒狀活性碳重量(g)	COD(mg/L)	COD 去除率（%）	COD(mg/L)	COD 去除率（%）
0.0	466		466	
0.5	393	15.7		
1.0	353	24.2	182	60.9
2.0	268	42.5	570	(22.3)
3.0	340	27.0	652	(39.9)

清潔劑名稱	**毛寶冷洗精**, pH=7.84			
振盪時間	30min		12hr	
粒狀活性碳重量(g)	COD(mg/L)	COD 去除率（%）	COD(mg/L)	COD 去除率（%）
0.0	678		678	
0.5	565	16.7		
1.0	547	19.3	243	64.2
2.0	492	27.4	256	62.2
3.0	454	33.0	648	4.4

振盪時間 30min 與不同量之活性碳的 COD 值與 COD 去除率總表（%）

清潔劑名稱	白蘭洗衣精	洗髮乳	嬌生洗手乳	妙管家洗衣精	毛寶冷洗精
活性碳重量(g)	COD 去除率（%）				
0.5g	19.8	18.6	21.9	15.7	16.7
1.0g	13.0	18.0	24.0	24.2	19.3
2.0g	29.4	16.5	16.0	42.5	27.4
3.0g	26.5	21.4	1.8	27.0	33.0



不同重量之活性碳的 COD 值與 COD 去除率（%）

單位重量清潔劑含營養鹽 NO_3-N、NO_2^--N、PO_4^{3-}濃度 ppm

清潔劑背景值					
	白蘭洗衣精	洗髮乳	嬌生沐浴乳	妙管家洗衣精	毛寶冷洗精
NO_3^--N	5.6	2.7	1.2	5.4	3.5
NO_2^--N	50.0	251.0	104.0	159.0	9.0
PO_4^{3-}	23.0	42.9	2.2	5.2	2.4

不同重量之活性碳背景值，振盪 12hr			
活性碳重量 營養鹽濃度 ppm	0.5g	1.0g	2.0g
NO_3^--N	0.83	0.67	0.86
NO_2^--N	4.54	2.91	18.29
PO_4^{3-}	0.18	0.58	5.24

不同清潔劑與同重量之活性碳混合後溶液營養鹽的濃度 ppm

活性碳重量(0.5g)	清潔劑名稱				
營養鹽種類	營養鹽濃度 ppm				
	白蘭洗衣精	洗髮乳	嬌生沐浴乳	妙管家洗衣精	毛寶冷洗精
NO_3^--N	6.6	62.2	2.4	7.5	2.4
NO_2^--N	102.7	191.8	237.6	113.9	11.6
PO_4^{3-}	34.1	30.9	10.9	15.7	5.4

活性碳重量(2.5g)	清潔劑名稱				
營養鹽種類	營養鹽濃度 ppm				
	白蘭洗衣精	洗髮乳	嬌生沐浴乳	妙管家洗衣精	毛寶冷洗精
NO_3^--N	1.2	43.4	1.5	7.7	3.8
NO_2^--N	184.8	213.0	210.2	106.7	17.9
PO_4^{3-}	25.0	48.0	10.6	24.8	10.9

活性碳重量(5.0g)	清潔劑名稱				
營養鹽種類	營養鹽濃度 ppm				
	白蘭洗衣精	洗髮乳	嬌生沐浴乳	妙管家洗衣精	毛寶冷洗精
NO_3^--N	4.0	32.9	1.6	10.6	2.9
NO_2^--N	155.1	197.2	169.2	117.3	18.8
PO_4^{3-}	21.0	47.9	9.5	25.9	13.0

活性碳重量(7.5g)	清潔劑名稱				
營養鹽種類	營養鹽濃度 ppm				
	白蘭洗衣精	洗髮乳	嬌生沐浴乳	妙管家洗衣精	毛寶冷洗精
NO_3^--N	8.1	12.3	2.8	10.8	9.3
NO_2^--N	245.8	124.2	75.8	188.7	29.8
PO_4^{3-}	29.1	22.3	15.5	19.9	24.5

活性碳重量(10.0g)	清潔劑名稱				
營養鹽種類	營養鹽濃度 ppm				
	白蘭洗衣精	洗髮乳	嬌生沐浴乳	妙管家洗衣精	毛寶冷洗精
NO_3^--N	5.6	28.6	4.6	8.8	6.0
NO_2^--N	215.6	229.4	36.0	28.7	37.9
PO_4^{3-}	39.7	23.7	19.5	23.6	37.5

清潔劑名稱	白蘭洗衣精					
營養鹽種類	營養鹽濃度 ppm					
活性碳重量	blank	0.5g	2.5g	5g	7.5g	10g
NO_3^--N	5.6	6.6	1.2	4.0	8.1	5.6
NO_2^--N	50.0	102.7	184.8	155.1	245.8	215.6
PO_4^{3-}	23.0	34.1	25.0	21.0	29.1	39.7

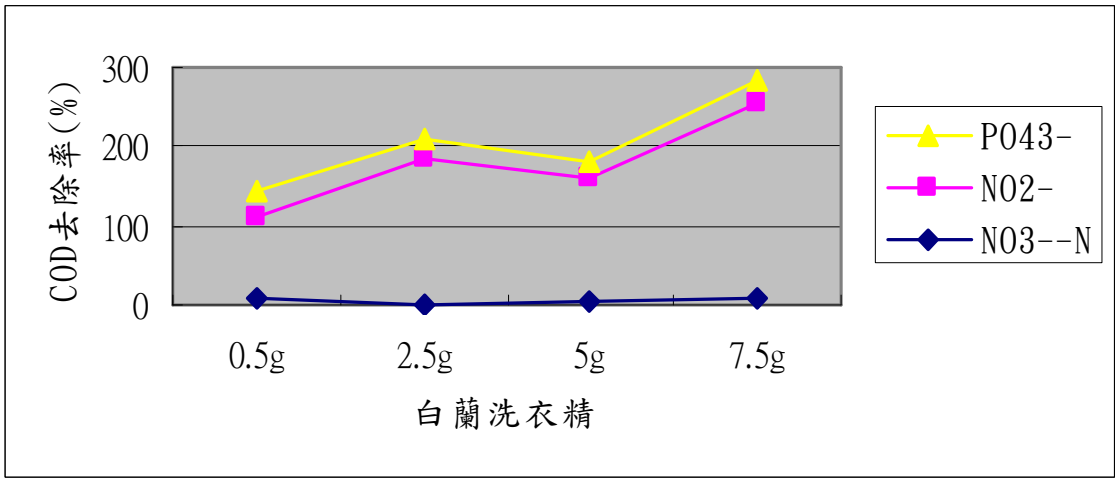
清潔劑名稱	洗髮乳					
營養鹽種類	營養鹽濃度 ppm					
活性碳重量	blank	0.5g	2.5g	5g	7.5g	10g
NO_3^--N	2.7	62.2	43.4	32.9	12.3	28.6
NO_2^--N	251.0	191.8	213.0	197.2	124.2	229.4
PO_4^{3-}	42.9	30.9	48.0	47.9	22.3	23.7

清潔劑名稱	嬌生沐浴乳					
營養鹽種類	營養鹽濃度 ppm					
活性碳重量	blank	0.5g	2.5g	5g	7.5g	10g
NO_3^--N	1.2	2.4	1.5	1.6	2.8	4.6
NO_2^--N	104.0	237.6	210.2	169.2	75.8	36.0
PO_4^{3-}	2.2	10.9	10.6	9.5	15.5	19.5

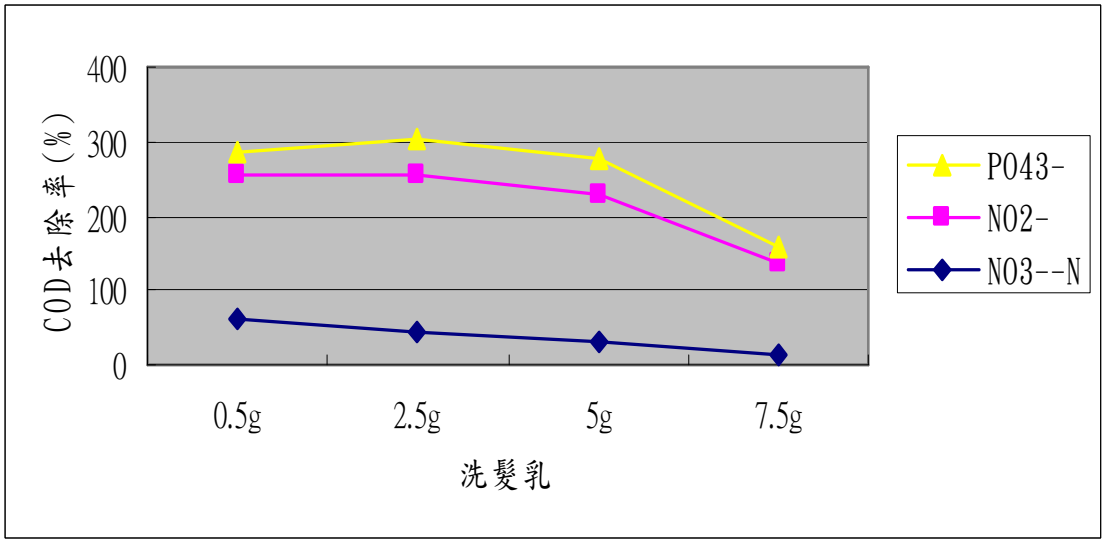
清潔劑名稱	妙管家洗衣精					
營養鹽種類	營養鹽濃度 ppm					
活性碳重量	blank	0.5g	2.5g	5g	7.5g	10g
NO_3^--N	5.4	7.5	7.7	10.6	10.8	8.8
NO_2^--N	159.0	113.9	106.7	117.3	188.7	28.7
PO_4^{3-}	5.2	15.7	24.8	25.9	19.9	23.6

清潔劑名稱	毛寶冷洗精					
營養鹽種類	營養鹽濃度 ppm					
活性碳重量	blank	0.5g	2.5g	5g	7.5g	10g
NO_3^--N	3.5	2.4	3.8	2.9	9.3	6.0
NO_2^--N	9.0	11.6	17.9	18.8	29.8	37.9
PO_4^{3-}	2.4	5.4	10.9	13.0	24.5	37.5

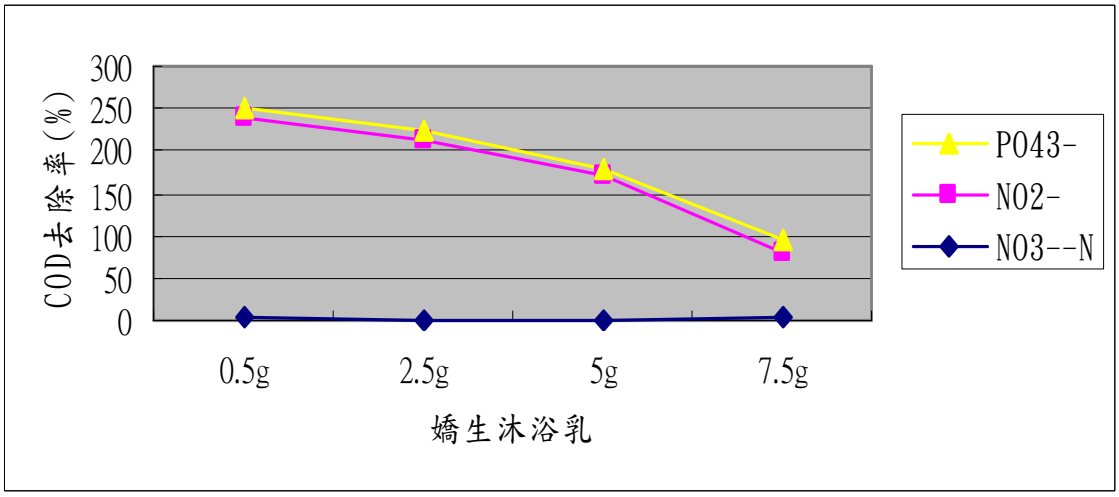
清潔劑名稱	白蘭洗衣精						
營養鹽種類	營養鹽濃度 ppm						
活性碳重量	0.5g	1g	2g	2.5g	3.0g	5g	7.5g
NO_3^--N	6.6	5.3	2.6	1.2	1.8	4.0	8.1
NO_2^--N	102.7	122.3	163.9	184.8	180.1	155.1	245.8
PO_4^{3-}	34.1	31.8	27.3	25.0	24.2	21.0	29.1



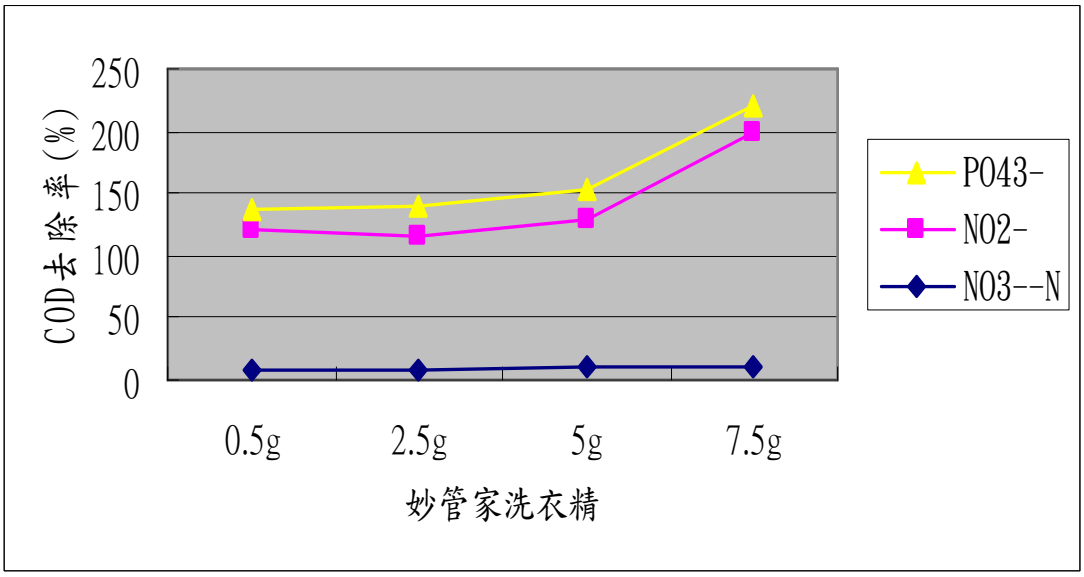
清潔劑名稱	洗髮乳						
營養鹽種類	營養鹽濃度 ppm						
活性碳重量	0.5g	1g	2g	2.5g	3.0g	5g	7.5g
NO_3^--N	62.2	57.5	48.1	43.4	41.3	32.9	12.3
NO_2-N	191.8	197.0	207.5	213.0	209.9	197.2	124.2
PO_4^{3-}	30.9	35.1	43.7	48.0	47.9	47.9	22.3



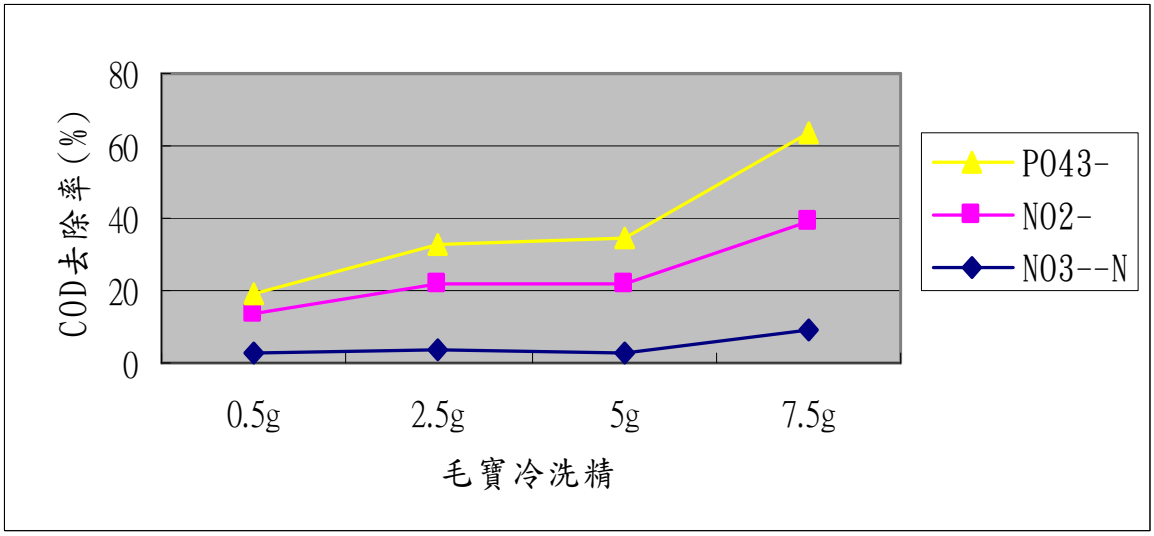
清潔劑名稱	嬌生沐浴乳						
營養鹽種類	營養鹽濃度 ppm						
活性碳重量	0.5g	1g	2g	2.5g	3.0g	5g	7.5g
NO_3^--N	2.4	2.2	1.7	1.5	1.5	1.6	2.8
NO_2^--N	237.6	230.8	217.0	210.2	202.5	169.2	75.8
PO_4^{3-}	10.9	10.83	10.7	10.6	10.4	9.5	15.5



清潔劑名稱	妙管家洗衣精						
營養鹽種類	營養鹽濃度 ppm						
活性碳重量	0.5g	1g	2g	2.5g	3.0g	5g	7.5g
NO_3^--N	7.5	7.5	7.6	7.7	8.3	10.6	10.8
NO_2^--N	113.9	112.1	108.5	106.7	108.8	117.3	188.7
PO_4^{3-}	15.7	19.0	22.6	24.8	25.0	25.9	19.9

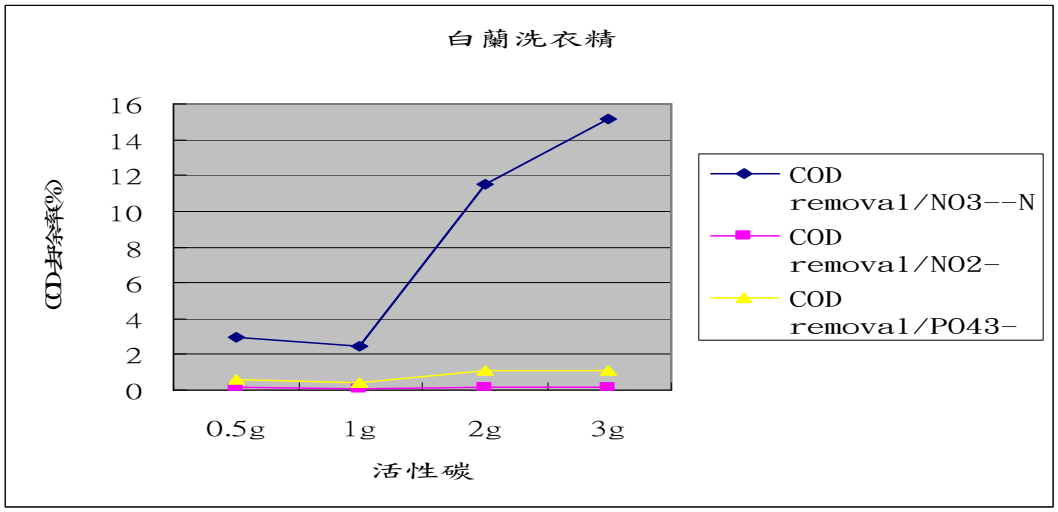


清潔劑名稱	毛寶冷洗精						
營養鹽種類	營養鹽濃度 ppm						
活性碳重量	0.5g	1g	2g	2.5g	3.0g	5g	7.5g
NO_3^--N	2.4	2.8	3.4	3.8	3.6	2.9	9.3
NO_2^--N	11.6	13.2	16.3	17.9	18.1	18.8	29.8
PO_4^{3-}	5.4	6.8	9.5	10.9	11.3	13.0	24.5

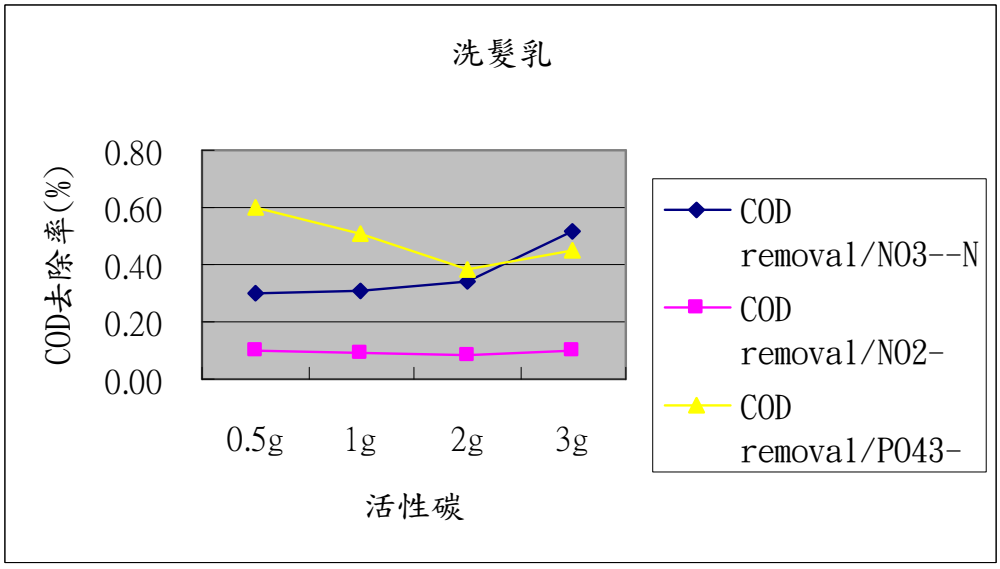


清潔劑名稱	白蘭洗衣精			
活性碳重量	0.5g	1g	2g	3g
COD removal/NO_3^--N	3.00	2.48	11.53	15.14
COD removal/NO_2^-	0.19	0.11	0.18	0.15
COD removal/PO_4^{3-}	0.58	0.41	1.08	1.10

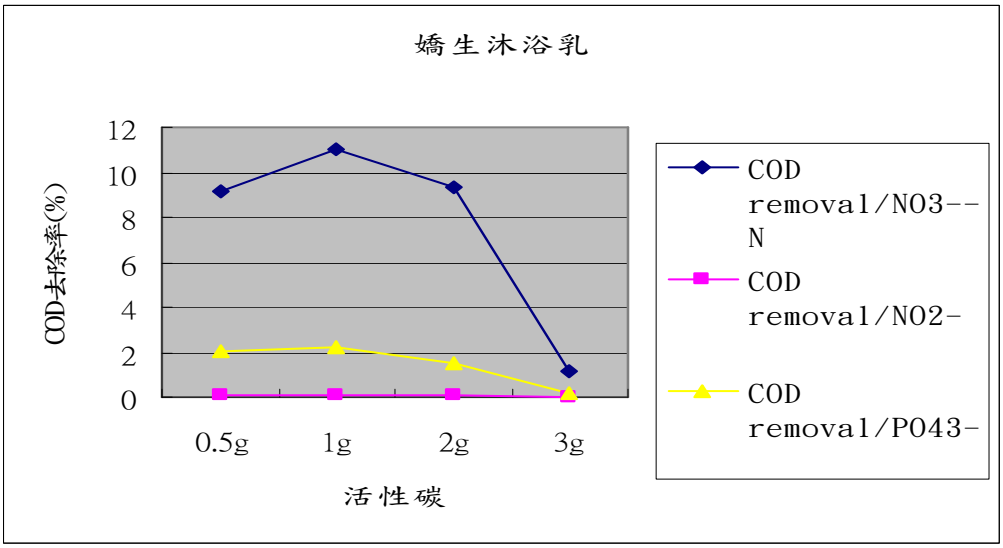
註：COD 去除率/NO_3^--N，0.5g--19.8/6.6＝3



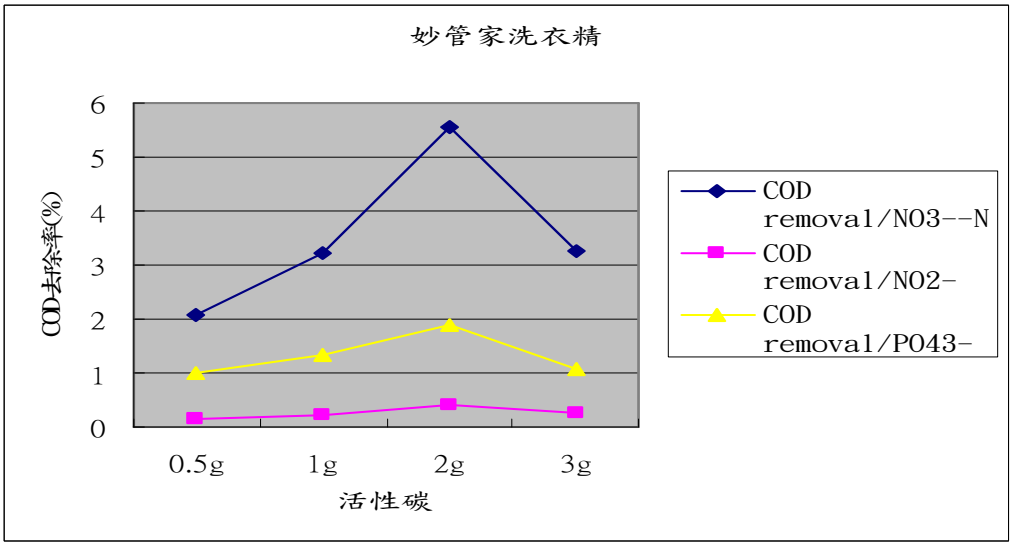
清潔劑名稱	洗髮乳			
活性碳重量	0.5g	1g	2g	3g
COD removal/NO_3^--N	0.30	0.31	0.34	0.52
COD removal/NO_2^-	0.10	0.09	0.08	0.10
COD removal/PO_4^{3-}	0.60	0.51	0.38	0.45



清潔劑名稱	嬌生沐浴乳			
活性碳重量	0.5g	1g	2g	3g
COD removal/NO_3^--N	9.13	11.06	9.30	1.19
COD removal/NO_2^-	0.09	0.10	0.07	0.01
COD removal/PO_4^{3-}	2.01	2.22	1.50	0.17



清潔劑名稱	妙管家洗衣精			
活性碳重量	0.5g	1g	2g	3g
COD removal/NO_3^--N	2.09	3.21	5.57	3.27
COD removal/NO_2^-	0.14	0.22	0.39	0.25
COD removal/PO_4^{3-}	1.00	1.35	1.88	1.08



清潔劑名稱	毛寶冷洗精			
活性碳重量	0.5g	1g	2g	3g
COD removal/NO_3^--N	6.96	7.02	7.97	9.17
COD removal/NO_2^-	1.44	1.46	1.68	1.82
COD removal/PO_4^{3-}	3.09	2.86	2.89	2.93