**2. Literature search and Selection Criteria**

In order to obtain a comprehensive dataset of adsorption studies involving selected pharmaceuticals on activated carbon derived from waste, a systematic literature search was performed using the Scopus database. The search period was restricted to 2010–present to capture contemporary research. Only scientific research articles were included, whereas reviews, retracted papers, and other non-primary sources were excluded to ensure data reliability.

To compile the dataset, keyword searches were performed in Scopus (**Table X**), which yielded a total of 2172 articles in the initial search. The keyword *waste* was deliberately excluded from the search to minimize the risk of missing relevant studies, as alternative terminology (*e.g.* residues, by-products, agro-industrial biomass) is often used to describe activated carbons. All retrieved articles were subsequently screened for relevance. Studies involving adsorption in non-aqueous or otherwise unconventional media (e.g., urine, solid matrices, or beverage extracts) were excluded. Likewise, studies limited to fixed-bed/column experiments were removed. Assisted adsorption processes, such as electro-adsorption were not considered. In addition, co- adsorption studies and investigations focused on activated carbon obtained via hydrothermal carbonization (hydrochar) were excluded. These criteria ensured that the final dataset was restricted to batch adsorption studies in aqueous media employing activated carbons produced from waste or biomass precursors.

**Table X:** An overview of the initial Scopus search results for pharmaceutical adsorption on activated carbon (2010–present), prior to application of exclusion criteria.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Scopus Search Keywords | Number | Years |
| 1 | ~~2-Phenoxyethanol\* AND “activated carbon” AND adsorption~~ | ~~3~~ | ~~2016 – 2020~~ |
| 2 | Acetaminophen\* AND “activated carbon” AND adsorption | 130 | 2010 – 2025 |
| 3 | ~~Acetylsalicylic acid\* AND “activated carbon” AND adsorption~~ | ~~25~~ | ~~2010 – 2025~~ |
| 4 | ~~Benzocaine\* AND “activated carbon” AND adsorption~~ | ~~1~~ | ~~2016 – 2025~~ |
| 5 | Caffeine\* AND “activated carbon” AND adsorption | 155 | 2010 – 2025 |
| 6 | Ciprofloxacin\* AND “activated carbon” AND adsorption | 200 | 2010 – 2025 |
| 7 | ~~Citalopram\* AND “activated carbon” AND adsorption~~ | ~~9~~ | ~~2017 – 2025~~ |
| 8 | Diclofenac\* AND “activated carbon” AND adsorption | 349 | 2010 – 2025 |
| 9 | ~~Fluoxetine\* AND “activated carbon” AND adsorption~~ | ~~22~~ | ~~2010 – 2025~~ |
| 10 | Ibuprofen\* AND “activated carbon” AND adsorption | 247 | 2010 – 2025 |
| 11 | ~~Metronidazole\* AND “activated carbon” AND adsorption~~ | ~~62~~ | ~~2010 – 2025~~ |
| 12 | ~~Naproxen\* AND “activated carbon” AND adsorption~~ | ~~105~~ | ~~2010 – 2025~~ |
| 13 | ~~Norfloxacin\* AND “activated carbon” AND adsorption~~ | ~~52~~ | ~~2010 – 2025~~ |
| 14 | ~~Oxytetracycline\* AND “activated carbon” AND adsorption~~ | ~~78~~ | ~~2011 – 2025~~ |
| 15 | ~~Salicylic acid\* AND “activated carbon” AND adsorption~~ | ~~67~~ | ~~2010 – 2025~~ |
| 16 | ~~Sulfadiazine\* AND “activated carbon” AND adsorption~~ | ~~34~~ | ~~2011 – 2025~~ |
| 17 | ~~Sulfamerazine\* AND “activated carbon” AND adsorption~~ | ~~9~~ | ~~2016 – 2025~~ |
| 18 | ~~Sulfamethazine\* AND “activated carbon” AND adsorption~~ | ~~32~~ | ~~2012 – 2025~~ |
| 19 | Sulfamethoxazole\* AND “activated carbon” AND adsorption | 283 | 2010 – 2025 |
| 20 | Tetracycline\* AND “activated carbon” AND adsorption | 313 | 2010 – 2025 |
|  | TOTAL: | 2172 |  |

Amoxsisilin neden yok! EKLENEBİLİR.

Bence sadece aktif karbon one step veya two step aktivasyonu sadece kimyasal aktivas

Şimdiye kadar – 499 makale tamamen gözden geçirildi ve tasniflendi. Kalanlar (7)

Tetrasiklin, sulfamethoxale, ibuprofen, diclofenac, caffeine, acetaminophen, ciprofloxacin.

Süper oldu aferin merve yarın buradan devam ….

Kalan üç malzemeyi diğer verileri topladıktan sonra yapacağım.

Buraya sadece adsorption ile çıkan sonuç sayısını yazıyorum o kadar.

Atık kelimesini aramaya bilerek eklemediğimizi de yazalım bence.

Bu çalışma için eligible olanları ayrı listeleyeceğim. Buraya açıklama yaz nasıl yapıtğına dair, sonrasında da şu Abraham solute parametersi bul, elimizde olmayan bir malzemeyi boşuna search etmeyelim o zaman. – benzoicane den sonrasında sorption yazarak da aratıyorum. Çıkarsa farklı bir şey not alacağım – sorptionda farklı makaleler çıkıyor listesini alıyorum onunda. Eğer sorptiondan veri aldığım bir makale olursa onu da sorption olarak searchlere eklerim ve kaç makale kullanılmış yazarım bence.

Not all reviewed and rectracted papers excluded dicem diğer her şeyi alıyoruz. Bunun yazısını yazacağım önce – burada hep 2010 ve sonrası arama yaptım ama bazı maddeler için yayınlar 2010 da başlamıyordu o yüzden tarihler farlı ama tabi bu yayınların hepsi veri için kullanılmaycak bu da belirtilmeli.

Bu bence böyle sunulmalı da kullanılan makale sayısını nasıl sunucam onu da yazmam lazım.

Kolon çalışmaları, ikili sistemler bunlar alınmadı dicem ama yukarıdaki veriler hepsi alınmış hali. Sonra seçtiklerimiz ayrı listelenecek. Uygun olmayam çalışmalar şu bu.

**ChatGPT:**

En son gönderdiğin özet (aktif karbonun **aerasyon tanklarına ve membran reaktörlere eklenmesi** ile mikrokirletici giderimi) → ❌ **sana uygun değil**. – bu tip çöalışmalar da var dikkate alınmaı de.

Şimdiye kadar 500 tane makaleye göz gezdirmişim.

Selective removal of acetaminophen in urine with activated carbons – ürede ve gerçek atık sularda çok örnek vardı bunlar alınmadı bahsedilmeli mesela kafein için de hep tea extracts coffee exkstraks ve coffee grounds vardı

The management of sewage sludge is currently an open issue due to the large volume of waste to be treated and the necessity to avoid incineration or landfill disposal. Hydrothermal carbonization (HTC) has been recognized as a promising thermochemical technique to convert sewage sludge into value-added products. The hydrochar (HC) obtained can be suitable for environmental application as fuel, fertilizer, and sorbent. In this study, activated hydrochars (AHs) were prepared from sewage sludge through HTC followed by chemical activation with potassium hydroxide (KOH) and tested for the removal of pollutants in gaseous and aqueous environments, investigating carbon dioxide (CO2) and ciprofloxacin (CIP) adsorption capacity. The effects of activation temperature (550–750 °C) and KOH/HC impregnation ratio (1–3) on the produced AHs morphology and adsorption capacity were studied by Response Surface Methodology (RSM). The results of RSM analysis evidenced a maximum CO2 uptake of 71.47 mg/g for mild activation conditions (600–650 °C

[Tailoring the porosity of chemically activated carbons derived from the HTC treatment of sewage sludge for the removal of pollutants from gaseous and aqueous …](https://www.sciencedirect.com/science/article/pii/S0301479723016754)

Bu çalışmanın başlığı aktif kabon ama aslında hydrochardanbahsediliyor başta bunları da almadığını yazabilirisn buraya.

Hydrothermal synthesis of 3D cauliflower anatase TiO2 and bio sourced activated carbon – by da mesela başka çakışma ama hydrothermal synesis var bir bunları almayacağız bence.

Mesela activated carbons derived from hydrochar were excluded. (sadece biochar olanları aldık) yani bu route ile üretlilenleri gibi.

Enhanced removal of selected ionizable micro-pollutants from drinking water by adsorption on activated carbon fiber filters under electrochemical assistance – bu tip elektro adsorption tarzı şwyler de gördüm onlar da yok.

Yarın Abraham solute parameters listesini çek ve onu da aynı bu şekilde açıkla bir paragraflar

# Table S3. Mean Qm and the number of samples by different pharmaceutical types

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | TP | mean | n | General use (ben ekledim) |
| ~~1~~ | ~~2-Phenoxyethanol~~ | ~~82.00~~ | ~~1~~ |  |
| 2 | Acetaminophen | 143.85 | 2 | antipyretic |
| 3 | Acetylsalicylic acid | 110.57 | 6 |  |
| ~~4~~ | ~~Benzocaine~~ | ~~51.40~~ | ~~1~~ |  |
| 5 | Caffeine | 47.43 | 6 | stimulant |
| 6 | Ciprofloxacin | 238.10 | 1 |  |
| ~~7~~ | ~~Citalopram~~ | ~~7.08~~ | ~~6~~ |  |
| 8 | Diclofenac | 34.95 | 15 | anti-inflammatory |
| ~~9~~ | ~~Fluoxetine~~ | ~~3.37~~ | ~~5~~ |  |
| 10 | Ibuprofen | 22.23 | 22 |  |
| 11 | Metronidazole | 167.50 | 1 |  |
| 12 | Naproxen | 228.00 | 1 | anti-inflammatory |
| 13 | Norfloxacin | 15.57 | 9 |  |
| 14 | Oxytetracycline | 28.85 | 12 |  |
| 15 | Salicylic acid | 29.28 | 5 |  |
| 16 | Sulfadiazine | 0.35 | 2 |  |
| ~~17~~ | ~~Sulfamerazine~~ | ~~0.67~~ | ~~1~~ |  |
| ~~18~~ | ~~Sulfamethazine~~ | ~~19.50~~ | ~~12~~ | ~~antibiotics~~ |
| 19 | Sulfamethoxazole | 62.13 | 9 | antibiotics |
|  | Tetracycline | 96.68 | 35 |  |

Atrazine (ATZ; C8H14ClN5)

2,4-Diclorophenoxyacetic acid (2,4-D; C8H6Cl2O3)

Triclocarban (TCB; C13H9Cl3N2O)

Bunlar yok bizde ama eklenebilir.

Bir liste yapacağım tüm farmasötiklerin bilgilerinin olduğu. – SMT3 de daha fazla bilgi var.

## Materials and chemicals

Table S1 Physic-chemical properties of Sulfamethazin and Sulfamethoxazole

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Antibiotics | Structural formula | CAS | Molecular formula  (molecular weight) | Melting points (℃) | pKaa | Solubility  (mg·L-1) | logKowb |
| SMX |  | 57-68-1 | C12H14N4O2S  （278.33） | 176 | 2.28  7.42 | 1500 | 0.89 |
| SMZ |  | 723-46-6 | C10H11N3O3S  （253.28） | 166 | 1.6  5.7 | 365 | 0.89 |

Note: a acid ionization constant, b octanol-water partition coefficient. SMT – 9 dan alındı. Supplementary

A screenshot of a computer

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Bunu amtalıya kopyala bu şekilde vermek de mantıklı iyonların dağıöımının

A white rectangular object with red and white objects on it

AI-generated content may be incorrect.

**Table S2**. Various types of biomass to product biochars from literature – Bu tablodan da hazırlamam lazım. 50 tane makale olunca direk modellemeye geçeceğim.

|  |  |  |
| --- | --- | --- |
| No | Biochar Types | References |
| 1 | Agro-waste | (Chakraborty et al., 2020, Dai et al., 2020, Jia et al., 2018, Jia et al., 2016, Luo et al., 2018) |
| 2 | Animal waste | (Chen et al., 2018, Li et al., 2017, Zhang et al., 2019) |
| 3 | Processing waste | (Calisto et al., 2014, Wan et al., 2016) |
| 4 | Sludge | (Ferreira et al., 2016, Liu et al., 2020, Oh and Seo, 2016) |
| 5 | River sediment, and forest residual and by-products | (Fernandes et al., 2019, Shen et al., 2020) |
| 6 | Plant with roots | (Chakraborty et al., 2018, Liyanage et al., 2020, Luo et al., 2020, Qin et al., 2017, Tan et al., 2020, Xu et al., 2020) |
| 7 | Invasive plant | (Rajapaksha et al., 2015) |
| 8 | Branch or body | (Essandoh et al., 2015, Jang and Kan, 2019, Jung et al., 2015, Li et al., 2018, Mondal et al., 2016, Tao et al., 2019, Zhang et al., 2018, Zhang et al., 2020) |
| 9 | *Spirulina sp.* algae | (Choi et al., 2020) |
| 10 | Composites e.g. agro-waste and clay, plant and attapulgite | (Li et al., 2016, Wang et al., 2019) |

**Data processing and input selection**

**Biocharlı olan makalede bu çok güzel anlatılmış onlar gibi yazmalısın üç ayrı basamak olarak anlatmışlar solute parameters vs.**

**Bu diğer çalışmalarım için önemli bir yazı:**

**O1 makalesinden**

**In addition, in the**

**adsorption progress, no attempt was made to maintain a constant**

**pH of the solution. Then, it was noted that the pH of all the solutions**

**decreased with adsorption and LSAC caused the large decrease**

**degree. Hasan et al. [39] suggested that the exchange of released H+ ions occurred between the surface of the adsorbent and solution**

**leading to the decrease of pH, confirming that the process of OTC**

**binding to the sorbent was predominantly in exchange of cations**

**(H+) present in the sorbent.**

**A screenshot of a computer

AI-generated content may be incorrect.**

**Veri de yaptıklarını anlat**

**% olarak verilenlere ne yaptın, dosage g olarak verildyse ne yaptın, mm gram verildiyse ne yaptın birimler ne sıcaklık vs için. % elementler için ne gibi gibi.**

**Yield is defined as g of activated carbon obtained per 100 gram of waste feedstock (bunu ben yazdım).**

**Table S3. Mean Qm and the number of samples by different pharmaceutical types**

**Aşağıya sadece elemental analiz sonucu olan verileri yazıyorum. Aslında daha çok ama onları kullanacağım ilk etapta. Bu kısım rahatça görselleştirilebilir. Veri seti yardımıyla çok kolay.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **TP** | **mean** | **No of data** | **No of AC** |
| **1** | **2-Phenoxyethanol** |  |  |  |
| **2** | **Acetaminophen** |  |  |  |
| **3** | **Acetylsalicylic acid** |  |  |  |
| **4** | **Benzocaine** |  |  |  |
| **5** | **Caffeine** |  |  |  |
| **6** | **Ciprofloxacin** |  |  |  |
| **7** | **Citalopram** |  |  |  |
| **8** | **Diclofenac** |  |  |  |
| **9** | **Fluoxetine** |  |  |  |
| **10** | **Ibuprofen** |  |  |  |
| **11** | **Metronidazole** |  |  |  |
| **12** | **Naproxen** |  |  |  |
| **13** | **Norfloxacin** |  |  |  |
| **14** | **Oxytetracycline** |  |  |  |
| **15** | **Salicylic acid** |  |  |  |
| **16** | **Sulfadiazine** |  |  |  |
| **17** | **Sulfamerazine** |  |  |  |
| **18** | **Sulfamethazine** |  |  |  |
| **19** | **Sulfamethoxazole** |  |  |  |
| **20** | **Tetracycline** |  |  |  |

**Farklı makalelerde asitlerin derişimi farklıydı ben asit kütlesine göre hesapladım bunu ekle – yani çözeltide ne kadar asit varsa o kadar / gram precursor**

**🔎 Özet “rule of thumb” senin veri setin için:**

* **Wet impregnation (solution, reflux, vb.): gerçek süre & sıcaklık yaz.**
* **Kneading/dry mixing: 25 °C, 0.1 h (dummy değer).**
* **Direct pellet mixing (çok hızlı): 25 °C, 0.01 h (dummy değer).**

**👉 Böylece hiçbir hücre boş kalmaz ve dataset tutarlı olur.**

**İmpregrnation işlemi yapılmadığında sıcaklık ve süreyi dummylerle doldurduğumdan bahset. Burada güzel bir mantık kurduk, hiçbir yer boş kalmamış olacak bu kısmı anlatmam lazım.**

**Kurutma kısmı da üretimde farklılıklar olduğu bazen empregnasyon aşamasından sonra kurutma yapıldğı (bazen yapılmadığı) ve bazen süzülerel bazen süzülmeden olması ve kurutmanın hep aynı sıcaklık ve sürede (kurutma için yeterli süre) bu kısım feature olarak alınmadı demeliyim**

**Data preparation and imputation**

**Aynı şeyi farklı h3po4ler için de yapmalısın. w/w e çevirme olayını**

**Bunu activation time a yaz örnek hesaplama ile beraber**

**The particles were placed in a quartz reactor and subjected to a pyrolysis process with N2 gas flow at 0.25 L min􀀀 1 and heating ramp at 10 K min􀀀 1 until 923.15 K. The reactor was maintained at 923.15 K for 80 min.**

**İf not stated impregnation temperature is assumed room temperature.**

**Ramp süresi dahil edilmedi**

**In activated carbon production, the activation time is conventionally defined as the dwell time at the target activation temperature, not including the heating (ramp) period. This is because the main pore development and surface reactions occur predominantly once the furnace has reached the activation temperature. The ramp time is largely dependent on furnace design, sample mass, and heating rate, and therefore introduces variability unrelated to the actual activation process. For this reason, only the dwell time at the activation temperature is considered as the effective “activation time.” – Aşağıdaki cptye yazdırıldı ama mantıklı bu neden bir gözden geçirilmeli ve kaynak eklenerek tutulmalı.**

**w/w olayında da eğer direct belirtilmediyse çözelti değil de asit kütlesi olduğu Kabul edildi diyeceğim. Cpt öyle önerdi çözelti verilse bile KOH: precursor diyorsa asit lütlesidir dedi. Metinde geçen ifade:**

***“…impregnated … in a weight proportion cork:activating agent of 1:1 and 1:2 … for KOH (Panreac, 85%) …”***

**Burada kritik ayrıntı: “weight proportion cork:activating agent”. Bu ifade, doğrudan aktif madde (saf KOH veya saf K₂CO₃) kütlesi baz alınarak yazılır. Yani:**

* **1:1 w/w demek: 1 g mantar (cork) için 1 g saf KOH kullanılmıştır.**
* **Eğer laboratuvarda %85 saflıkta KOH kullanıyorsan, gereken çözelti/katı miktarı:**

**mKOH (c¸o¨zelti/katı)=msaf KOH0.85m\_{\text{KOH (çözelti/katı)}} = \frac{m\_{\text{saf KOH}}}{0.85}mKOH (c¸​o¨zelti/katı)​=0.85msaf KOH​​**

**Örnek**

* **10 g cork için 1:1 oran → 10 g saf KOH gerekir.**
* **Senin elindeki %85 KOH ile:**

**Ml olanlarda hesaplama gerekli sadece M55 gibi onu örnek olarak yazarsın ya da molar olarak verilenlerde belki**

**Ya da dur değiştirdiklerimi buraya not alayımyani hesaplama gerektirenleri**

**M55 (ml verilmişti)**

**Sa60 (öncesinde direct %50lik çözelti ile deniyor)**

**Burada şöyle dicem eğer yanlışsa bile solution to precursor denmediği sürece böyle Kabul edildi diyeceğim.**

**SA67 yi mesela bakma hidrojen katalizörü olarak denedikleri bir yayından buldum diğer her şey aynıydı**

**Some missing data is found aynı yazarın aynı malzemeyi sentezlediği – diğer koşulların aynı olduğu makalelerinden de alınmıştır dicem**

***Burada önce kimyasalları listele***

***Sonra aktivasyon oranını ne yaptık anlat nasıl bulduk.***

***Activation Temperature – if this data was missing the paper is not used.***

**Data Handling mi hepsi bunları bişiy bulmak lazım- başa da kaç veri boştu ba**

**Soak temperature and time (Soak\_time & Soak\_temp)**

***Burda da başlangıçta kaç veri boştu bahset.***

Published protocols describe impregnation with inconsistent wording and incomplete details (e.g., “mixed, washed and dried”, “overnight”, “kneaded into a paste and then dried at 100–110 °C”, or “mixed and directly carbonized”), which makes direct comparison and modeling unreliable. To create a consistent dataset while preserving the intent of the original methods, we normalized all soaking conditions into three mutually exclusive categories with simple, transparent rules.

1. **Explicit Soak:** For **explicit soak** reports, we used the reported duration and temperature. If temperature was unspecified, we assumed room temperature (298.15 K), and if duration was described as “overnight,” we standardized it to 12 h.
2. **Mix-to-Paste, Drying-Assisted Route:** In these studies in which the precursor is kneaded, shaken, or otherwise mixed to form a paste and then oven-dried at **dried** (at any reported oven temperature (at any reported oven temperature—e.g., 36 °C, 70 °C, or 100–110 °C) and where no separate soaking procedure is reported, we assumed impregnation continues only during the early drying stage while solvent is still present; accordingly, we set:

*Soak\_Time = min(Drying\_Time, Cap(T))*

*Soak\_Temp = Drying\_Temp,*

where **Cap(T) = 6 h for T ≤ 70 °C and 4 h for T > 70 °C**. If drying time was unreported Soak\_Time=Cap(T). If temperature was unreported, Soak\_Temp was set to 105 °C, the midpoint of the typical 100–110 °C range.

1. **Direct pyrolysis (no-soak):** For descriptions that proceed from mixing straight to carbonization, we assigned a minimal non-zero dummy of **0.1 h at 25 °C**, acknowledging brief handling/contact without fabricating a substantive soak and avoiding hard zeros for downstream modeling.

Papers note several alternatives for immediate post-impregnation handling (*e.g.,* washed and filtered, filtered, washed, and dried, or washed to neutral pH and dried). In our normalization, impregnation post-processing was not considered and thus did not modify Soak\_Time or Soak\_Temp. Operationally, these steps remove excess reagent and solvent, neutralize residual acidity/alkalinity, and standardize moisture/solids content before carbonization; they do not extend impregnation or materially affect the resulting active carbon structure under routine conditions (neutral washing, ≤110 °C drying) and are treated as preparatory, not structure-determining, steps in the preparation of activated carbon.”

**Carbonization Atmosphere:**

In the dataset, carbonization atmosphere appears as a categorical variable reported under three conditions: N2 flow, air flow, and cases with no mention of any flow. In the latter case, it can be inferred that carbonization occurred in a closed furnace under a self-generated atmosphere. Thus, even if ‘self-generated’ is not explicitly stated, the absence of any specified atmosphere or flow was considered as self-generated. No missing entries were observed for this variable.

**Activation heating rate (K** **min⁻¹):**

Among 999 total rows, 790 reported an activation heating rate (20.9%). The distribution is discretized to five values (3, 5, 10, 15, 20 K min⁻¹) a median of 10 K min⁻¹ and an interquartile range (IQR) spanning 10–15 K min⁻¹. Frequencies are 10: 48.1% (380), 15: 27.8% (220), 20: 11.1% (88), 3: 7.6% (60), and 5: 5.3% (42). IQR-based mild outlier fences (2.5, 22.5) indicate that the observed range (3–20) falls well within expected bounds, supporting a simple, reproducible imputation policy.

Heating rate can influence pore development, volatile release, and the balance between activation and carbonization, and is often shaped by the reaction atmosphere. A bar chart of row percentages across oxidative versus inert (N2) atmospheres illustrates this tendency, showing systematic differences between oxidative and inert processing. To explore this relationship more deeply, we constructed two heat maps of heating rate against temperature band, stratified by atmosphere (oxidative vs. N2). These visualizations revealed context-dependent patterns: N2 carbonizations were almost exclusively carried out above 773 K with an average heating rate of 10 K min⁻¹, whereas oxidative processes were more frequently applied at lower temperatures (<1023 K) and showed systematic variation across ranges. Specifically, under oxidative conditions ~60% of cases below 773 K reported 10 K min⁻¹, while ~88% of cases between 773–1073 K reported 15 K min⁻¹.

A screenshot of a graph

AI-generated content may be incorrect.**Figure X.** (a) Distribution of activation heating rates, (b) 100% stacked Atmosphere × heating rate percentage distribution, (c) Temperature band × heating rate — inert atmosphere (N₂), (d) Temperature band × heating rate — oxidative atmosphere (Air + SG).

On this empirical basis, we established a deterministic imputation policy: 10 K min⁻¹ for inert steps, 10 K min⁻¹ for oxidative steps (including air and self-generated volatiles without N₂) below 773 K; and 15 K min⁻¹ for oxidative steps above 773 K.

**Şimdi operating conditions:**

**Burda güzel bi mantık geliştirdim ama bundan sonrakilerin dolumu için phzpc hariç çok detaylı uğraşmayacağım elastic search ve lasso yapıp sonuçlar üzerinden tekrar bakacağım.**

Bunlar da aslında feature crosslar olarak eklenebilir – Atmosphere X rate ve temperature X rate gibi. (MANTIKLI)